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Practical Methods of Conservation of Manpower in Theatres of Operation

By Lieut. Col. Jay W. Grissinger, G. S.

INASMUCH as the subject under discussion touches the Medical Department so vitally and, as the writer has the honor of being a member of the Medical Corps, it is considered almost entirely from a medical viewpoint.

Methods for conserving man power at the front will differ in accordance with the variety of warfare in operation. Under the conditions of modern warfare as they existed in the A.E.F., and it is from this experience that our conclusions are drawn, the problem immediately assumes two phases—one associated with trench warfare, the other with open operations.

A. TRENCH WARFARE

The problem here is a comparatively simple one where definite methods can be put into effect with the certainty that much can be accomplished toward keeping the maximum number of men at the front at all times.

(1) *Permanent hospitalization* can be provided close to the front line so that except for such serious cases as is evident will not be again fit for combat duty or at least will not be fit for a long time, all sick and wounded can be hospitalized near the front and under the immediate control of the local (division) commander. In quiet sectors in France, such hospitals were sometimes within 10 to 15 kilometers of the front line. When fit for active combat duty, patients from these hospitals are returned immediately to their own organizations thus avoiding the great delay inevitably connected with return of men to

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the front from hospitals in the Zone of the Interior. In this way, the necessity for replacements is reduced very appreciably and there is as well a very decided saving in transportation required to send them back and forth. An added advantage is that men can always be returned to the organization to which they belonged when sent to the hospital. This frequently fails of accomplishment when men are sent to hospitals in the rear. Undoubtedly it is a great stimulus to morale if men know they will be returned to the organization in which their friends are serving and with whose officers they are thoroughly familiar, assuming of course, that their previous record has been good and their relations with their officers and noncommissioned officers reasonably satisfactory.

Further, the very early surgical treatment which such advanced hospitalization renders possible will in the long run mean a saving of many days in hospital for wounded and especially for the slightly wounded whose rapid recovery depends entirely upon early expert attention. It may in an individual case mean the difference between a few days incapacity and one stretching over months or even ending in permanent disability through infection.

It is evident therefore that the nearer the permanent hospitalization facilities to the front consistent with reasonable safety, the greater the saving of man power which will ensue.

Similarly, the saving in time for the sick and especially the slightly sick is equally obvious.

(2) *Venereal disease.* This is always a cause of serious wastage unless vigorous but sensible methods are employed for its control. A.E.F. achievements in this respect were really remarkable due in very large measure to the full realization by the Commander-in-Chief of the great importance of the matter and his complete and vigorous support of every measure needed for solution of the problem. An organized campaign along practical lines will save many men for combat duty who would otherwise be incapacitated, and generally for long periods of time.

The method employed in the 42d Division during trench warfare in the Luneville-Baccarat sector in the spring of 1918 brought most gratifying results. In brief, it was as follows:—

a. Daily contact with troops of the division was maintained by the Division specialist (Urologist), who was constantly circulating in the area imparting information wherever needed, inspecting prophylactic stations, discovering sources of infection, supervising treatment of all known cases, and, in collaboration with local authorities, hospitalizing infected women wherever found. His attitude with troops was always one of helpfulness, and not a critical one.

b. Establishment of the necessary prophylactic stations, conveniently located, kept clean and with trained personnel on duty at all hours.

c. Periodic examination of all men in the command by their respective medical officers. They were advised of the value of prophylaxis and were urged to avail themselves of it, particular stress being laid upon the necessity for early application.

d. Establishment of a venereal hospital. Every case discovered of whatever stage or degree of acuteness or chronicity was sent at once to the venereal hospital. No cases were treated for even a day in their organization. This operated to relieve the regimental medical personnel from a class of cases which were most troublesome to them and for the proper treatment of which they had neither the necessary equipment nor in most cases the experience or special training necessary to insure prompt recovery and return to combat duty. Furthermore, it removed from sick in quarters a class of case which is not only detrimental to the morale of the sick man's associates, but is distinctly dangerous as a possible source of serious infection to others.

This venereal hospital departed from the usual hospital of this character in several particulars.

Certain other nations in the war had a great amount of wastage of front line troops from venereal diseases due in large measure to the practice of sending their cases to the rear for treatment. They were thus not only lost to the front for long periods of time but, as is seen at once, a premium was placed upon the acquisition of venereal disease in that it served as a means of securing transportation to the comforts and safety associated with Zone of the Interior hospitals. It has been said that men on occasion deliberately infected themselves from the discharges of an infected comrade in order to escape front line duty.

Our first thought then was to obviate this source of wastage, and for that reason the venereal hospital was placed as close to the firing line as conditions warranted. By that is not meant that these men were subjected to any greater danger than their uninfected comrades, but neither were they subjected to any less. By this means the incentive of acquiring venereal disease for the purpose of getting away from the front was removed. In the Luneville-Baccarat sector, this hospital was placed in a clump of woods somewhat in advance of the towns in which troops were billeted when out of the trenches. They were within moderate range of enemy gun fire, just as the troops were. In this woods a field hospital with special equipment and a small selected personnel was placed. This field hospital was completely equipped with every drug, instrument or apparatus necessary for a thorough and complete course of treatment in any case no matter how slight or severe. It was placed under the immediate professional charge of the Division Specialist (Urologist) and to it were assigned medical officers who were specialists in this class of diseases. The division medical personnel was carefully canvassed in order to place in immediate command of this organization the officer best fitted by virtue of executive ability and

tact to handle the difficult problem. The governing policy in administration was to make men feel not that they were pariahs but that they were sick men for whom we were furnishing the most expert treatment possible. Discipline was firmly applied but with absolute justice so far as our judgment rendered this possible. It was said by experts who inspected the camp that patients received as expert treatment as they could have had in the best hospital of New York City and far more effective inasmuch as they were under military discipline. Excellent results were immediate. The men were comfortable, keen about their treatment and as contented as anyone can be who is suffering from a loathsome disease. But, most important of all, they were returned to combat duty in much less time than ever occurred under the old system, and the operation of this hospital together with well applied prophylaxis and periodic inspections soon reduced the venereal problem of the division to a negligible factor.

Another important feature was the utilization of the patients in accordance with their physical condition. For this they were placed in three classes:—

(a) Those whose condition was such that it was necessary to keep them in bed. This was a very small percentage.

(b) Those able to be about but not able to do any heavy work. It was essential of course that such men be kept constantly busy. To accomplish this, they were utilized to keep the camp thoroughly policed and in addition were given daily light drills, instruction in first aid and especially in all phases of gas warfare and the best methods to avoid becoming a casualty from this cause, and such other light duty as could be developed. Much was done in the way of special work such as weaving baskets, improvising utensils from salvaged material for use in the camp and such other work of this character as facilities permitted.

(c) Those able to do any kind of labor. These were sent out daily, usually by truck to whatever point needed for any kind of work required in the division area—road making, road repair, trench digging or what not. In this way their services were not lost to the division while at the same time they were under daily inspection by specialists and received expert treatment and consequent early return to full duty with their organization. Certain cases of syphilis after the first course of treatment was completed and their condition warranted it, were returned to their command until time for their next course came around, usually a month, when they were again taken to hospital, given the next course, then returned to command again and so on to completion of treatment.

The layman will naturally ask why such men who are physically able to do any kind of work should not be immediately returned to their organization. The answer is that they are suffering from a communi-

cable disease which is extremely apt to recur especially under the conditions surrounding field service.

By keeping them a little longer in hospital under expert observation and treatment, they can be gotten into such condition that recurrence is not likely and in the long run therefore they will not only spend more actual days with their organization, but will be decidedly more efficient from a physical standpoint.

It must of course be emphasized that this applies only to trench warfare where the demand for man power on the firing line is not so insistent. In open operations, these men must without question take their place in the line and remain there until relieved or disabled.

The result of this campaign was that when the division left the trench sector in June, 1918, for participation in open warfare in the Champagne and shortly after at Chateau-Thierry, not more than a half dozen men were kept out of these engagements by reason of venereal disease.

As will be noted later, the venereal problem in open warfare is a very different one from that just described and must be handled on entirely different lines.

(3) *Bathing and delousing.* During the long years of trench warfare, an enormous wastage resulted from infestation of men with lice and resulting skin infections. Men became infested immediately upon entering the trenches and remained so until relieved and deloused. At one time, it was reported that 90% of the time lost by English soldiers from illness was due to skin infections.

To control this source of wastage, the following campaign was inaugurated in the 42d Division in the Luneville-Baccarat sector:—

Three bathing and delousing plants were provided in the area occupied by the Division—one on the right and one on the left of the area and about midway between the front and rear and one small plant near Division Headquarters to serve such headquarters and auxiliary troops as were too far from the other advanced plants for efficient service from the latter. These plants each had facilities for hot shower baths and for disinfesting of clothing by steam. They were placed near an ample water supply in wooded areas so as to be out of sight of the enemy.

In order to insure systematic bathing and delousing, a schedule was adopted for the entire Division whereby each organization was given a time each week when it must report with every available man at one of the plants mentioned. Each organization was ordered to appear in charge of an officer so that control was maintained at all times. The Division Commander heartily supported the campaign so that there was no difficulty in carrying it out effectively. As a matter of fact, the men derived so much comfort from the plan in operation that they soon became enthusiastic and no difficulty was experienced in having

them report—they were eager for it. In fact, certain men whose work was in such places that they became infested every day reported daily at the plant and were put through the process.

An ample supply of hot water for showers was always available and soap and towels were furnished. While the men were bathing, their clothing was disinfested by steam and was reissued or new clothing furnished upon completion of the bath.

The steam plant was a portable Thresh-Foden apparatus with two large steam chambers. This plant soon developed several very useful features in addition to bathing and delousing.

(a) Clothing issue. Before adequate bathing and laundry facilities were established in the division, it was found that men very often wore their underwear until it became very much soiled and then simply threw it away. This of course was a great waste of clothing. Men reported at the delousing plant with no underwear or with underwear so soiled as to be unfit for further use until washed, or so worn as to require replacement. Similarly their outer clothing was often unfit for further use and had to be renovated or replaced.

To meet this, a supply of clothing of all sorts and of assorted sizes was placed in the clothing room at the delousing plant. Any man whose clothing was too soiled or worn for re-issue, was given a fresh supply without the necessity of going through any formality. He was also encouraged to return it to the window in case of poor fit and get a better fit in exchange.

(b) In order to care most efficiently and economically for the exchange of clean for soiled clothing, a portable laundry was placed adjacent to the plant so that soiled clothing after disinfestation was immediately sent to the laundry. Immediately upon completion of the laundering, the clothing was returned to the clothing room for re-issue.

The whole plan worked so well and was so clearly in the line of economy and efficiency that it soon followed that all issue of clothing in the division was accomplished at the bathing and delousing stations.

(c) Inasmuch as skin diseases were such a potent source of wastage of manpower during trench warfare, it was realized that a vigorous campaign was essential in order to control this source of trouble. Early detection and early treatment were absolutely necessary in order to reduce the time cases were lost to combat organizations.

To accomplish this, intelligent noncommissioned officers were selected and given special instruction in the detection of skin diseases by a specialist of long experience. These noncommissioned officers were then assigned to the delousing stations. Their duty was to place themselves in the shower room and there carefully observe every man who passed through. No man who was found with a skin disease was permitted to rejoin his organization, but was immediately sent to a hospital especially equipped to care for him. The line officer in charge of the

organization was given a list of all such men so disposed of so that their whereabouts were known to the Company Commander.

By this systematic examination, over 400 cases of skin diseases of all sorts ranging from slight infections to infections of the most severe type covering almost the entire body were discovered and sent to hospital within the first two weeks. By the end of 6 weeks, however, less than 20 cases were on sick report and when the division entered open operations, no men were incapacitated from this cause.

4. *Skin disease hospital.* In order to complete the system for elimination of skin diseases, a special hospital was erected for their treatment. This was accomplished by adapting one of the four field hospitals. No change was required in its equipment beyond the addition of cots and such special drugs as are required for this class of infection. The officers were given special instruction by a specialist. Treatment was very simple but required systematic and vigorous application. This hospital was located well back in the area on the banks of a stream so that a plentiful supply of water was available. As in the venereal camp, it was a tent hospital. Also, as in the venereal camp, a certain number of these men prior to their return to duty, were able to do manual labor and were sent out wherever and whenever needed. This was not only beneficial for their general physical condition, but kept them more contented and was a distinct saving in manpower. As noted in the discussion on venereal disease one might well ask why, if they were able to do manual labor, they were not returned to their organization. The answer is that the great majority of them were suffering from scabies which is a contagious disease. Furthermore, if returned too soon, the condition was very apt to recur so that their retention for the full time required resulted in the end in a decided saving in time to the organization.

The whole campaign against skin diseases was so successful that, by the time the division left the trench sector for participation in open operations, the necessity for this special hospital had about disappeared and from that time on it is probable that the few cases remaining could have been properly cared for in the hospital established for medical cases in general.

Unless some effective organization is put into operation for the control during trench warfare of the diseases which have just been discussed, the loss of manpower which will result will, in a campaign against an enemy of equal strength or at least capable of effective resistance, assume most serious proportions at an early date and will compel vigorous measures to reduce the wastage.

B. OPEN OPERATIONS

We now turn to a consideration of the more important phase of the problem, namely conservation of man power in theaters of operations

during open warfare. It is here that the maintenance on the firing line of every possible man is of vital importance and it is here also that many more causes operate to deplete the combat troops. Though many difficulties are encountered and it is by no means possible to avoid all leakage, proper organization will save, in a strenuous campaign involving large numbers of men, many hundreds or perhaps thousands to the firing line who otherwise would filter back to the rear.

Sources of wastage will be considered under their respective appropriate headings.

1. *Litter bearers from line troops.* Long before American troops were engaged in open operations during the World War, it was evident that the small Medical Department personnel allowed per regiment would be wholly inadequate to care for the large number of casualties which were bound to occur. The only solution that appeared feasible was the use of line troops to augment this scant personnel.

This same difficulty was encountered in the English Army and was met in a similar way. This was a makeshift arrangement which the Medical Department deplored but which was unavoidable in the circumstances.

Dependence upon Medical Department personnel alone would have meant that wounded men unable to walk would have remained unattended on the field for long periods. It constituted a real source of wastage of combat troops inasmuch as troops used for this purpose had to be strong, sturdy men. It was most trying and exhausting service calling not only for a high degree of courage, but for superior physical make-up. Men so detailed were unavailable for any other duty. As an illustration of just what was done in the 1st Corps of which the writer was Chief Surgeon, the following order is quoted:

"Headquarters First Army Corps,
American Expeditionary Forces,

"Memorandum: July 30, 1918.

The following recommendations of the Corps Surgeon are approved and will be at once put into operation in organizations of the 1st Army Corps and those serving therewith.

(a) That twelve men from each rifle and machine gun company of each infantry regiment and two men from each battery position of each artillery regiment be turned over to the Regimental Surgeon for training in first aid, including application of splints, litter bearing and handling of gassed casualties. One hour's training every day until proficient, after which, two hours each week.

(b) That these men shall be available at all times in active periods for use by the Regimental Surgeons for the above duties.

(c) That they be not armed but that they be supplied with dressings, splints and litters.

(d) That they wear around the left arm a blue brassard with the letters L.B. in white.

(e) That they be used for no other purpose during periods of activity than litter bearers.

(f) That they accompany working parties and all reliefs so that they will always be on hand in case of necessity. When accompanying such parties or reliefs, they should be required to do no other duty.

(g) During rest periods they should be returned to their organizations and take up the regular routine except for the two hours weekly drill as outlined above.

This work is so important that none but high class, sturdy, intelligent men will be selected. The selection of men who are in any way physically or mentally below par will not be made. The good effect upon the morale of troops of the knowledge that if wounded they will be skilfully handled and quickly and comfortably carried to hospitals cannot be overestimated. The bad effect of less efficient service is obvious.

By command of Major General Liggett:

W. A. Haverfield,
Major, N. A., Adjutant."

Enemy prisoners were of course utilized wherever and whenever available, but naturally this was a variable factor and one not to be depended upon.

It will be seen from the above order that twelve of the best men were thus lost to combat duty from each Infantry company, to say nothing of those lost to the other organizations.

For future emergencies the new Tables of Organization for the Medical Department provide a partial remedy for the above deficiency. Medical personnel in an Infantry regiment has been increased from 48 to 87. In place of the litter bearer sections of the former Ambulance Companies, a medical regiment has been provided which includes a sanitary battalion containing 306 enlisted men of which 249 are privates 1st class and privates. This gives a further increase of men who can be utilized as litter bearers. Being under the immediate control of the Division Surgeon, they can be shifted from place to place as necessity demands. This will still leave the Medical Department with a considerable shortage which must be made up from other sources. It is of course not probable that the Medical Department will ever have enough men to take care of the peak load in a strenuous engagement when casualties are high. In any severe operations, we will still have to call on the line for assistance, but a forward step has undoubtedly been taken in the new tables and the Medical Department will in consequence be in better shape to meet its obligations than has ever been the case in the past.

The obvious remedy for this source of wastage is, of course, allotment to the Medical Department of sufficient personnel to take care of the casualties which occur.

2. *Gas Casualties.* With the introduction of gas warfare, a new and potent source of wastage of troops came into being. For men who are actually gassed, there is no action possible other than immediate and rapid transportation to the rear—they are lost to the firing line for a varying period of time depending upon severity and character of the dose in the individual case. Control of this wastage must naturally be

accomplished by prevention and depends therefore upon supplying the soldier with an effective mask and teaching him how and when to use it.

However, there is a very large avoidable wastage due primarily to the fact that it is practically impossible for the medical officer in the front line and in the excitement of combat to differentiate between a real gas case and a pseudo-gas case in such instances where the infection, if any, is slight. In the well marked case of course there is no difficulty. In the slight case on the other hand, even the most expert specialist may be unable to tell definitely except after observation covering several hours at least.

It was astonishing, during the Chateau-Thierry offensive especially, to see the hundreds of cases of this character who came back to the field hospitals with a diagnosis tag indicating "gas poisoning" and in which, so far as a superficial examination would show, there appeared no evidence of real disability. The greatest care had to be exercised however in passing final judgment on these cases. After an hour or more certain ones would show unmistakable signs of gas poisoning and their immediate removal to the rear became necessary.

In order to stop this leakage, a definite plan was put into operation in the 1st Corps.

In the first place, all field hospitals of a division were grouped in one spot so that in this way all casualties passed back through this one point—the front was always narrow enough to render this entirely practicable. One field hospital out of the four was designated as the gas hospital to which was referred every gas case or suspicious case that came back from the front. This hospital was provided with a portable shower bath and other necessary equipment and supplies to provide proper preliminary treatment. At this hospital was placed a specialist on gas poisoning with necessary assistants. This specialist passed on every case that came through, selected such cases as required immediate evacuation to the rear, and supervised all treatments. Those cases in which he felt certain no gas poisoning was present were given such care as seemed necessary and returned to their organization in the line. Cases which were doubtful and required further observation were segregated and their progress watched. As soon as it became evident that they had a real infection, even though it might be slight, they were evacuated to the rear. Similarly as soon as it became certain that no gas poisoning existed, they were returned to the front.

As may be imagined, this saved many men from being transported back to base hospitals. It not only avoided a great wastage from the firing line, but also prevented able men from occupying beds in base hospitals which were badly needed for real casualties.

From the above, it must not be assumed that these men were malingerers. Perhaps some of them were but the great majority were victims of exhaustion for whom several hours sleep, food and a shower did

wonders. They were then able to again resume their full duty. They were held sometimes as long as 24 hours before being finally disposed of.

In order to minimize to the limit of our ability the evacuation to the rear of cases which had no real infection, those cases which showed no definite symptoms but in which there was still a doubt as to whether they had really been gassed, were held in the field gas hospital as long as circumstances permitted before final disposition. The limiting factor of course was the fact that field hospitals must be kept evacuated in order that they could properly care for the constant stream of casualties from the firing line. However, such cases as the above were segregated to one side and so did not seriously interfere with the evacuation of real casualties.

During such periods of stress when it was impossible to hold any cases at the division field hospitals longer than the time required to give the necessary care and secure transportation, it was of course necessary to provide another means of preventing cases with no real disability from getting to the rear.

Similarly many men coming to the field hospital group had thrown away their arms and probably also their equipment so that they could not be returned directly to their organization until this equipment had been replaced. To a certain extent, this can be met by salvaged material but obviously this cannot always be the case.

To meet these difficulties, the Corps Sanitary Train was utilized. The composition of the Sanitary Train was exactly the same as the Division Sanitary Train—4 Field hospitals and 4 ambulance companies. It however was placed considerably farther back and was not subject to the sudden and frequent changes which are inseparable from divisional formations. The field hospitals composing it were grouped at a selected and easily accessible point. This was known as the Corps Rest Camp.

To this point were brought all slightly wounded, slightly gassed, and slightly sick. Facilities were better for their care than was possible in the divisional units and it was possible to keep for a much longer period such selected cases as experience indicated would be fit for duty within a few days. This of course relieved base hospitals of just that much strain and enabled us to return such cases promptly upon recovery to their respective divisions.

Also suspected gas cases and men suffering from exhaustion alone could be held here long enough to definitely establish their status and without danger of injury to the individual for sufficient facilities for their care were on hand.

In addition, a supply of clothing and equipment was kept here so that men coming back from the divisions without equipment and who could not be supplied at the division field hospital group were supplied and promptly returned to their proper division.

Further close liaison was maintained with the evacuation hospitals.

draining the Corps. Evacuation hospitals are mobile hospitals belonging to the Army and are the first organizations which the wounded man reaches where proper facilities are provided for surgical treatment. Though well equipped for surgery, patients can be kept here only a short time for these hospitals must be kept constantly evacuated in order to take care of the great stream of wounded returning from the front. By this liaison, such cases who slipped through the division formations by oversight or error but who were not really incapacitated in any way or at least so slightly as to not warrant evacuation, were promptly transferred from the Evacuation Hospital to the Corps Rest Camp. At this point, they were cared for, equipped and promptly returned to their proper division.

3. *Nervous cases—so called "shell shock."* In general, the same remarks apply as were made under gas casualties. In a severe and prolonged engagement involving large numbers of troops, many men, neither wounded not gassed, will find their way to the group of divisional field hospitals. A certain proportion of these cases will be real casualties whose nervous systems have given way under the terrific conditions surrounding modern warfare. The only possible disposition of such cases is immediate evacuation to the rear. However, there will be a considerable number, varying of course with the severity and duration of the engagement, who are sent back with diagnosis tag marked "shell shock" but who present no real disability and it is these cases whose evacuation farther to the rear must be prevented both from the standpoint of conserving man power for the front, and of avoiding congestion of hospitals in the rear with individuals who should never get farther back from the field hospital. Here again as in gas casualties, examination by an expert is necessary in order to determine which are real casualties and which are not. The place to establish this fact is at the group of field hospitals for this is the neck of the bottle through which all cases must pass. It is here that the Division psychiatrist with necessary assistants takes station. All cases coming in the psychiatric class are carefully segregated and examined by the specialist. As with gas cases, all who present no real disability are returned to their organization—the others are evacuated at once to the rear.

The dividing line between the real nervous casualty and one who has no real disability from this cause is considerably clearer than is the case with gas casualties. Moreover it is not often necessary to hold cases for some hours for development of symptoms as in gas cases so that the problem is somewhat easier of solution.

4. *Exhaustion.* Repeating to a certain extent what was noted under gas and nervous casualties, attention is directed to the fact that the great number of men who will filter back to the field hospitals under the two classes given above, gas and "shell shock," but who have no real disability are suffering from pure exhaustion. Obviously these

men should not be permitted to continue their way to the rear. Likewise it is obvious that they are not in condition for immediate combat duty. It is surprising to see how they brace up after several hours sleep, some food and where available a shower bath. They are then in condition to return to their organization. Under the prolonged physical effort and mental stress of modern warfare, the number of such cases coming back to field hospitals is very great and in a prolonged engagement involving large numbers of troops will run into many hundreds or even thousands.

If not stopped at the field hospitals, these men get into the tremendous current of evacuation from which once entered there is no escape and they are transported back through the Evacuation hospital until they finally come to rest in a base hospital many miles in the rear. If this happens, they are lost to the front for many days, probably weeks, and when returned are more than likely to find themselves in a new outfit. And of course when they reach a base hospital, they occupy beds which in time of great activity will be badly needed for a real casualty.

Evacuation hospitals are so tremendously busy that there is no time for the weeding out of cases. Those who do not require surgical intervention are loaded on to the first hospital train available and sent to the rear. This of course means an avoidable loss of many days to the front line for every man so transported who has no real disability.

In order to assist in the weeding out of the disabled from those not disabled, a specialist in internal medicine and a surgeon of good judgment and experience are stationed with the specialists in gas and nervous diseases at the group of field hospitals. Their function is to supervise medical and surgical treatment and to assist in every possible way to prevent the passage to the rear of those who should be returned to their command. The particular function of the medical specialists is to examine all cases of exhaustion to determine if any real disability exists and to return to the front all whom he finds fit for combat duty.

5. *Slightly wounded.* In so far as the maintenance of the full strength of the command at the front is concerned, the slightly wounded man is of far more importance than the severely wounded. In the case of the latter, no matter how skilful may be the care and treatment, he is lost to combat duty for a long period if not permanently. The former on the other hand may be returned to the front in a very short time, perhaps a matter of days. Everything depends on early expert treatment inasmuch as prompt healing of his wound depends upon the avoidance of infection. The man who applies the first aid treatment is likely to be the individual on whose shoulders rests the responsibility for early recovery and return to duty. Even though carelessness is practiced here, the surgeon and his assistants at the group of field hospitals may still prevent trouble by their careful supervision and readjustment

of dressings improperly applied or which have become disarranged during transporattion.

The number of slightly wounded will run into thousands. As in other cases, their evacuation all the way to the rear should be avoided if possible for this means a long delay before their return. To meet this, the convalescent hospital is designed. This is a cot hospital of 5000 capacity placed as well to the front as possible and under control of the Army commander. One is provided for an Army. To this hospital, the slightly wounded and slightly sick and possibly also slightly gassed are sent. By this means their return to command is very much expedited and in addition beds are saved in base hospitals for those who need them most. This organization supplements the Corps Rest Camp discussed under gas casualties.

From the foregoing, it will be noted that at the group of field hospitals, there is stationed personnel capable of appraising every variety of disability that gets to this point and of passing expert opinion upon their proper disposition.

At the risk of tiresome repetition, let me emphasize strongly that without an adequate organization to handle this problem, the resulting loss in man power will become a matter of most serious concern not only to you in the front but to your colleagues in the rear who have to transport and care for this constant stream of pseudo-casualties. The only possible place to accomplish control effectively is at the group of field hospitals because, as stated before, this is the first point through which *all* casualties must pass before they get into the stream of evacuation to the rear. The methods outlined have been put to the test of real battle in the A.E.F. and have passed that test successfully.

6. *Venereal and Skin Diseases.* The problem of venereal and skin diseases is very different in open warfare as compared with trench operations.

In active operations, against an enemy of strength approximately equal to your own or in any case where resistance is considerable, the crying need is to maintain at the front every available man. The fact that a man has a chronic venereal or skin infection cannot of course be permitted to interfere with his presence with his command. The policy should be to get into the line every man who is physically capable of fighting and keep him there until he is actually disabled. The only venereal cases which should be relieved from combat duty under these circumstances are those which have such complications that they are actually physically disabled. This however will be a very small percentage. Similarly only such skin disease cases which are so severe as to produce real disability should be kept away from combat duty.

BURIAL OF THE DEAD

At first glance, burial of the dead appears to have no connection

with the question of conservation of man power for when a man is dead his value as a fighting unit is ended. However, the question does have a bearing on the matter under discussion inasmuch as burial required man power to effect it and the source of the man power to be utilized for this purpose directly touches the question at issue. Furthermore, it is of sufficient importance to warrant a few moments' discussion.

In trench warfare, the matter is easily solved and does not usually affect the front line beyond the loss of the individual killed. The body is brought back by either Medical Department or line troops and burial effected in a formal way in a regularly designated cemetery.

In open operations however in a strenuous campaign of some magnitude against a stubborn and resourceful enemy the problem at once assumes very great importance especially if the campaign is in the summer months.

When the 1st Corps entered the Chateau-Thierry campaign, it became evident almost at once that some vigorous action to accomplish prompt disposition of the dead men and animals was imperative. In the hot sun, bodies decomposed very rapidly and soon created a frightful stench. This in itself was not dangerous but the decomposing bodies formed a favorable place for the propagation of flies and soon they were breeding by millions. This of course created a very serious sanitary menace and as was to be expected was promptly followed by a widespread outbreak of intestinal disturbances.

The problem that confronted us therefore was the prompt disposition of dead men and animals, both from a sanitary standpoint and that of morale. Burial of dead men had to be accomplished systematically so that future identification was possible.

Paragraph 349, Field Service Regulations, U. S. Army 1914 provides—"* * The dead are collected by *details from the line* as soon as practicable after the battle and disposed of as the commander directs." This provision of course was made at a time when battle conditions were very different from those confronting us in the A.E.F. Battles were of comparatively short duration and involved much fewer men. We can assume that it was reasonably satisfactory or otherwise some other plan would have been evolved.

But with conditions as they were in the A.E.F., with these provisions alone, the command was almost helpless and it became evident at once that it was necessary to organize something which would be able to handle the problem promptly and efficiently.

Under the conditions of modern warfare where troops are maintained in the line for some days under the most strenuous conditions, the utilization of combat troops for this purpose cannot be too strongly condemned for the following reasons:

1. Troops which have been in a strenuous battle under modern

conditions are so exhausted after their relief from the line that calling upon them for further labor and especially of this character is indefensible.

2. The labor involved, especially in the burial of animals, is very heavy and troops who have been in action are not fit to undertake it. On the other hand, the strength of troops in reserve must of course be conserved so that they go into action as fresh as possible. Their utilization for this purpose therefore likewise becomes most inadvisable.

3. In order that unsanitary conditions be avoided, burial must be prompt. Utilization of combat troops defeats this for serious delay is bound to occur.

4. Lastly, the influence upon morale of having troops exhausted from action called upon to bury their late comrades is the worst imaginable. Every individual confronting the swollen and discolored remains of his recent associates will picture himself in exactly the same condition every time subsequently thereto that he goes into action. If on the other hand in returning from the engagement he sees the field cleared of the gruesome reminders of the recent conflict, he will subconsciously conclude that the affair was not so bad after all.

Similarly the use for this duty of reserves who may be called upon any minute to go into action is just as unwarranted if not more so, for it is more important to have men go into action in a high state of morale than it is to lower their morale after having passed through the ordeal.

Bodies of course must be buried and cannot be burned. It is impossible to obtain sufficient fuel for the purpose and furthermore the light would simply serve to draw enemy fire on the position.

Consideration of all these facts brought the conclusion at once that a special body of men was required whose sole duty during the engagement was burial of the dead. This conclusion received the immediate support of the Commanding General of the 1st Corps and for this purpose one company of Pioneer Infantry was detailed to report to each division just prior to the jump-off. Later this was increased to two. The following extract from paragraph 11, Annex 9, "Plan of Communications, Supplies, and Evacuation" of Field Order 57, Headquarters, 1st Army Corps, September 22, 1918, illustrates what was done to meet the situation.

"Burials—

(a) Every effort will be made to promptly and properly bury the dead and secure proper identification.

(b) Dead animals will be promptly buried.

(c) To bury the dead and to promptly dispose of dead animals, each front line division has been furnished with one company of Pioneer Infantry. These companies will be dispatched so as to arrive not later than noon of D-1.

These troops will be reported to and work under the direction of the Divisional Sanitary Inspector."

Later orders specifically stated that these troops would be used for burial of dead men and animals and for *no other duty*. At first they were ordered to report to the Division Quartermaster and to work under his direction. It was promptly discovered however that this left something to be desired because the Quartermaster had other very important duties to which he naturally gave precedence. Thereupon the order was changed to provide that these troops report to the Divisional Sanitary Inspector and work under his immediate direction. This was the logical assignment as it is primarily a sanitary question. From that time on, our problem was solved—the battlefield was cleaned promptly and it was most gratifying as you went forward to note the absence of dead bodies on the recent field of action. The Pioneer Infantry did most excellent service. On one occasion they followed so closely behind the firing line that several were killed. This of course was decidedly disadvantageous but it indicates that they were really on the job.

Of course we had minor difficulties from time to time in carrying out the system as for example when a certain division commander insisted on using these Pioneer Infantry troops for other duties which he considered more important—road building, getting food up to the front, etc. However, a little pressure from the Corps Commanding General who was thoroughly in sympathy with the plan soon effectually cleared away the obstacle.

Aside from the special phases of the question which have been discussed, there are other elements of course which enter into the conservation of man power at the front.

Such for instance is the important problem of the straggler. With well disciplined troops possessed of high morale and under capable leaders, the straggler problem will be a negligible one. Poorly disciplined troops or poorly trained officers will of course result in many stragglers in either event. Under our traditions and form of Government, it is very difficult to provide the first combination, that is, where a major emergency is concerned and a large part of the manhood of the nation is called upon to bear arms.

Needless to say, straggling not only seriously reduces the man power on the firing line but also has a most deleterious influence upon the morale of every combat soldier who comes in contact with the straggler. The root of the matter lies in training and discipline and particularly in the training during peace of a large body of officers in the art of handling men for it is a real art. Those officers who have the art of implanting and maintaining in their men the proper amount of pride and the willingness to fight will have no real difficulty.

Lacking properly trained officers in sufficient numbers, and our past history indicates that we always will lack it to a certain degree at least, the question of straggling will probably always be with us. To control

it, there must, it seems to me, be a definite organization provided whose sole duty during periods of strenuous activity will be to take care of the straggler—to root him out and return him to the firing line. No man of course should ever be permitted to pass to the rear without an absolutely compelling reason as for example a wounded man or the bearer of an important message.

Such duty will require energy, courage, intelligence, judgment and force of character, and only men of a high type should be delegated to perform it. In order to be effective, their attention must not be distracted by other duties at the same time for this will simply result in one or the other being performed in a perfunctory and therefore inefficient manner.

Another important matter is the subject of the utilization during an attack of the protection afforded by inequalities of the terrain. I venture to mention this largely because of a criticism contained in a German document captured during the American advance at Chateau-Thierry. This criticism paid high tribute to the valor of the American soldier but stressed the fact that in their total disregard of the protection afforded by inequalities in the ground, their advance was accompanied by an unnecessarily large number of casualties. I believe there is something in this and further that this same strenuous advance resulted in an abnormally large number of cases of physical exhaustion.

In studying this problem, a number of things must be taken into consideration. For instance, if one is dealing with untrained troops, it may be and conceivably will be advisable and perhaps necessary, once they have started on the assault, to permit them to continue without interruption. Any other course would be apt to result in considerable disorganization.

But let us assume reasonably well trained troops.

Too much care in the utilization of inequalities of the ground in an assault will result in such diminution of that dash and vigor so essential in an Infantry attack as to seriously endanger the chances of success.

Further, by prolonging the engagement, it is possible that the final total number of casualties will be actually increased.

Too much caution must also have a depressing effect on the morale of the attacking force by giving them too much time during which they may consider their position, by unduly magnifying in their imagination the danger incident to the operation and the necessity for such extreme caution.

On the other hand, total disregard of possible protection will undoubtedly result in an unwarranted increase in casualties though here of course the moral effect on the enemy of a steady, vigorous and ruthless advance must be given due weight.

The object of any assault must be to deliver at the point of impact the greatest number of men in the best possible physical and mental

condition, that is, physically able and mentally willing to fight. It is of little practical value to deliver men to the point of actual physical contact with the enemy who, though mentally willing to fight, are physically too exhausted to deliver an effective blow. Similarly, it is equally disastrous to bring men to this point in good physical condition but of low morale. The two elements therefore, physical ability and mental willingness (morale) enter into every phase of the problem and will be given equal consideration by the wise commander.

A prolonged continuous advance paying no attention to the protection afforded by the terrain enroute will not only reduce the number of men by casualties on the way but will bring the remainder to the actual objective in a more or less exhausted condition and therefore not in the best condition to deliver the final thrust which may be necessary to accomplish the desired result.

Proper utilization of protection on the way will not only leave fewer casualties on the way and thus bring more men to the final point of actual physical contact with the enemy, but, by the interval or intervals of rest, momentary though they may be, will enable the men to come to grips in a reasonably vigorous condition.

So that, it seems to me, the middle ground in this respect is the wise course. It is one which will call for experience, good judgment and quick decision which must necessarily be left finally to the individual on the ground. Preliminary training however covering the principles which should govern should accomplish much in preparing the young officer for this phase of his work.

Lastly, it seems scarcely necessary to direct attention to a fact known to all officers of experience, namely, that back of all our efforts to keep fighting men on the firing line up to the very limit of their physical and mental make-up, lies the fundamental question of discipline and morale.

Lack of the latter intangible quality makes a man quit before he is hit while a goodly supply of it keeps him fighting though he may be mortally wounded.

It affects the whole problem most vitally. High discipline and morale will keep not only the number of stragglers to a minimum but likewise that group which has previously been discussed under the heading of exhaustion, a considerable number of whom differ only from the straggler in that they have on them a diagnosis tag which entitles them to move to the rear.

It will be noted that in this discussion practically nothing has been said on the question of sanitation and preventive medicine. These tremendously important questions have been omitted advisedly and not by oversight. Their consideration involves an entirely different phase of the subject and one concerned more largely with the Zone of the Interior.

Position Finding by Airplane

By Captain George W. Ricker, C. A. C.

Editor's Note: Here is something which every Coast Artillery officer should read. In this, his preliminary report, Captain Ricker, commanding Battery D, 52nd Artillery, has furnished a remarkably concise and clear cut statement of the initial experiment in a method of long range fire control whose subsequent development, if vigorously exploited wherever possible, bids fair to revolutionize the potentialties of coast defense armament.

1. *A statement of the problem.* The problem was set forth in various communications and papers as follows:

a. An outline of the problem was given in the following letter from the Chief of Coast Artillery and the Chief of Air Service:

WAR DEPARTMENT
Office of the Chief of Coast Artillery
Washington.

April 25, 1922.

Subject: Joint Coast Artillery and Air Service Training.

To: The Adjutant General of the Army.

Extract.

* * * * * *

3. The immediate problem consists of the determination of the possibilities and limitations of each of the arms in joint operations in coast defense and the development of training methods which will insure efficient cooperation of the two arms in developing to the maximum their combined defensive power.

4. The following program is proposed:

a. Cooperation of Coast Artillery and Air Service in Coast Defense.

(1) Conduct of fire.

(a) Determination of relative suitability of airships, captive balloons, and airplanes in conduct of fire.

(b) Determination of ranges and conditions at which air observation is preferable to ground observation.

(c) Experimental work in control of fire at targets beyond the range of vision from shore.

* * * * * *

(Sgd) M. M. PATRICK
Chief of Air Service.

(Sgd) F. W. COE
Chief of Coast Artillery.

b. The portions of the problem to be carried out at Fort Story were those indicated in paragraph 4 *a* (1) (*b*) and (*c*) of the above letter and were specifically set forth in the following instruction sheets issued by the Joint Board:

JOINT COAST ARTILLERY AND AIR SERVICE TRAINING

Test at Fort Story, Wednesday, November 8, 1922.
(Note: this test was postponed until November 14th)
Firing on Hypothetical Course between Anchored Targets.
Firing Data to be Determined by Airplane.

1. Five pyramidal targets (designated by number from right to left, looking seaward,) will be planted in a line about 17,000 yards from Fort Story. Distance between targets about 2,000 yards. The exact position of these targets will be indicated to the master of the ship which plants them.

2. At 10.00 AM, an airplane from Langley Field to be over No. 1 target, and report position of target No. 1 by indicating the square on the magnetic grid map. The airplane will also report the speed and direction of a hypothetical target which moves at such speed as to pass the successive positions of the anchored targets at intervals of six minutes.

3. Fire for deliberate adjustment with 14-inch gun at Fort Story on simulated position of moving target represented by fixed targets. Airplane to report deviations.

4. Based on airplane data the battery will prepare firing data and fire at the proper time so as to engage the hypothetical moving target at the instant it would be at the position marked by target No. 2. Airplane to report deviation of shot from target No. 2 by means of the clock code. In a similar manner, fire will be directed at targets Nos. 3, 4, and 5.

5. Test to be repeated as outlined above. Airplane to make a second estimate of position, speed, and direction of the hypothetical moving target and fire to be opened up on targets 2, 3, 4, and 5, as outlined above.

6. Test to be repeated a third time if, in the judgment of the Board, it is deemed advisable.

7. Previous to this firing, battery commander will fire six trial shots. Based on the trial shots he will make the necessary ballistic corrections before opening fire on the hypothetical moving target.

8. The Mine Planter *Schofield* will take position in prolongation of the line of the planted targets and 2,000 yards West of No. 1 target. Range rake and camera readings will be taken of each splash.

9. Commanding Officer, Battery D, 52d Artillery, will make the necessary arrangements to plot the position of each anchored target and the position of the *Schofield* prior to the firing. He will also arrange to have base end observers observe and record the azimuth of each splash. The plotted deviation of each splash to be recorded.

10. Commanding Officer, Battery D, 52d Artillery, is charged with the conduct of the firing and will make all necessary arrangements for

keeping of records. He will detail an observer to observe and record lateral deviations from the battery.

11. Major E. Montgomery, C. A. C., is detailed as Safety Officer for this practice and will make the necessary arrangements for safety of the field of fire and observing vessel.

FOR THE BOARD:

(Sgd.) BENJ. N. BOOTH,
Major, C. A. C.,
Executive.

JOINT COAST ARTILLERY AND AIR SERVICE TRAINING
Test at Fort Story, Thursday, November 9, 1922.

(Note: This test was postponed to November 15th and 16th)

Firing on Towed Target. Firing Data to be Determined by Airplane.

1. The Mine Planter *Schofield* to be in a designated position off Dam Neck Mills at 10.00 a. m. The *Schofield* to tow one target. Length of towline, 2,000 yards. Course to be towed will be designated to master of ship. Orders to commence towing will be given by radio.

2. Lieutenant McFadden is charged with all arrangements for towing of target, and for range rake and camera details.

3. At 10.00 a.m., an airplane from Langley Field to fly over target and report its position, course, and speed.

4. Based on airplane data, open fire with 14-inch gun on towed target. Airplane to report deviations by the clock code. Based on these deviations the battery commander will correct the reported position, course, or speed as may be necessary.

5. Commanding Officer, Battery D, 52d Artillery, will make the necessary arrangements for keeping of all records. He will detail an observer to observe and record lateral deviations from the battery. He will determine the azimuth of the target at the instant of splash. He will have a course plotted of the target and will make the necessary arrangements for base end stations to observe and record the azimuth of each splash.

6. Major E. Montgomery, C. A. C., is detailed as Safety Officer for this practice and will make the necessary arrangements for safety of the field of fire and towing vessel.

7. Major Booth will be at Fort Story during this practice.

FOR THE BOARD:

(Sgd) BENJ. N. BOOTH,
Major, C. A. C.,
Executive.

c. Stated briefly, there were two phases of the problem:

(1) To fire on a hypothetical moving target depending solely upon

the airplane observer for position finding. This was the preliminary or preparatory phase.

(2) To fire upon an actually moving target depending solely upon the airplane observer for position finding. The object was to make a practical service test of the feasibility of such a procedure.

2. *A statement of any special methods used in the training of the organization.* I do not know that the method of training employed could be called a "special method." It is the only practical method known to me and consisted in the main of three steps: first, the paper organization of the battery, by which I mean the determination of the tasks or duties necessary to be performed; second, the selection of the men to perform the various duties; and third, the actual training by careful and methodical instruction accompanied by the inevitable changing about process until each man has a task that he can perform efficiently and each task has assigned to it a capable man. The daily training was divided into three periods: first, a period of drill; second, a period of theoretical instruction combined with appropriate practical demonstrations; and third a period for the cleaning, care, and adjustment of matériel. The detailed method of training and instruction is set forth in the following schedule:

BATTERY D, 52D ARTILLERY,
FORT STORY, VIRGINIA.

October 13, 1922.

Schedule of Drills Effective October 16, 1922.

8.15 to 9.30 A M	Artillery drill daily. Observers' and readers' instruction, to include setting up and orienting instruments, care and nomenclature of instruments; drill in tracking, reading, and recording. Senior NCO present to be in charge each day. Range section drill daily.
9.30 to 10.30 A M	Cannoneers' instruction. Gun section, ammunition section, and reserve section. Instructors, Lt. Hartman, Sgt. Bryson, and Sgt. Newman. Instruction will cover the following points for all members of the above sections. 1. Caliber and model of cannon. 2. When and where built. Type (wire-wound). 3. Carriage—type and model, where built. 4. Nomenclature, location, and purpose of all important parts of gun, carriage, and foundation. 5. Recoil and counter-recoil system in detail. 6. Ballistic properties, muzzle velocity, limiting elevations, range, etc. 7. Breechblock, firing mechanism, and safety devices in detail. Obturation, what it is, and how accomplished.

8. Powders, projectiles, fuzes, and primers. Proper loading of projectile and powder. What happens when lanyard is pulled, in detail.

9.30 to 10.30 A M — Range section instruction. All members of the range section. Instructors, Capt. Ricker, Lt. Griffin, 1st Sgt. Briggs and Sgt. Jones.

Instruction will cover the following points:

1. Fire control systems in general, purpose and method.
2. Plotting Board 110°; nomenclature, location, and adjustment of the various parts. Tests for accuracy and adjustment.
3. Plotting Board, Whistler-Hearn; same as above.
4. Range correction board; purpose, nomenclature, care, and adjustment.
5. Meteorological message; what it is, how used.
6. Deflection board; purpose, operation, etc.
7. Telephones, what they are, proper use and care.
8. Observing instruments; use, nomenclature, care, and adjustment.
9. Special methods and matériel for airplane fire control, in detail.
10. Necessity for care and accuracy. Analysis of drill, purpose and method.

10.30 to 11.30 A M — Special work, construction and repairs, care and preservation of matériel.

1.00 to 3.00 P M — Care and preservation of matériel. Special work. Drill and instruction when ordered.

Fridays at 9.30 — Artillery inspection: will include inspection of matériel and personnel and questions and tests to determine state of instruction and proficiency.

Saturdays at 9.00 — Inspection under arms followed by inspection of quarters.

(Sgd) GEORGE W. RICKER,
Captain, 52d Artillery,
Commanding.

3. *A statement of preparations made for firing.* The preparations for firing were as follows:

a. Orientation. The gun position and secondary station were located by a surveying party from Fort Monroe. These locations were checked by 1st Lieutenant W. E. Griffin (range officer) and myself by means of triangulation and conversion of geographic coordinates to grid coordinates in accordance with Special Publication No. 59, U. S. Coast and Geodetic Survey. The primary station at Dam Neck Mills was located by Lieutenant Griffin from a nearby primary traverse station of the U. S.

Geological Survey. The length of the base line was 8,089 yards. B′ was 16,017 yards from the gun position and B″ 7,932 yards.

b. Plotting room and range section equipment. In the plotting room preparations were made to carry on simultaneously two independent operations: first, to receive the data from the airplane observer and to translate it into firing data with no reference whatever to any other data or information; and second, to plot the course of the target in the usual manner by the horizontal base system and to predict the position of the target at the instant of firing and at the instant of impact, in order that the safety officer might be able to compare the actual position of the target with the set-forward-point determined from the airplane observer's data and hold the fire in case of danger. The track by the horizontal base system was also necessary for purposes of analysis and for subsequent determination of the comparative accuracy of the track obtained from the airplane. (The method of procedure in the plotting room will be discussed in detail in paragraph 5.) The plotting boards were adjusted and checked; the range board was checked; the elevation deflection board was checked and compared with the range table.

c. The gun and its accessories. The gun was oriented for laying in direction by means of an aiming point. The sight and sight standard were tested and adjusted. The elevation quadrant was tested and adjusted by means of the master quadrant from Fort Monroe. It was not possible to use a clinometer for this purpose as no 14-inch bore rest was available. The recoil cylinder was drained, cleaned, and refilled. The by-pass throttling valve was disassembled, cleaned, and carefully examined. It was locked in the closed position. The bore and powder chamber were thoroughly cleaned and freed from grease and oil. The breechblock was disassembled, all of its parts carefully examined, and was adjusted for firing. The firing mechanism was examined and tested, and the safety device was tested with unfired service primers in the prescribed manner. It was necessary to have the local ordnance machinist manufacture a safety bar slide and housing as there was none on the gun. The lanyard was inspected. The primers to be used in firing were all inserted in the firing mechanism to be sure that, in firing, none would stick or jam. The elevating and traversing mechanisms were examined, cleaned, and lubricated. The ram cylinders were drained, cleaned, and refilled. (Note: the ram cylinders with their shoes, which bear upon the support beam segments, are devices to resist and check the overturning moment of the carriage at the instant of recoil). As the support beam segments (3 in number) allowed a field of fire of only 18° and the field of fire to be used was about 30°, it was necessary to improvise an additional support beam segment. This was done by the use of steel I-beams in the manner shown in the accompanying photograph. See Figure 1. A is a support beam segment. B shows the use of the I-beams. C is another support beam segment.

D is the ram cylinder and shoe, and E is the rear end of the carriage. The small size of the rear platform of the gun carriage made it virtually impossible to load the piece with any degree of speed or facility. To overcome this difficulty a loading platform was constructed by 12 x 12 blocks and timbers. The projectiles were placed on the platform pre-

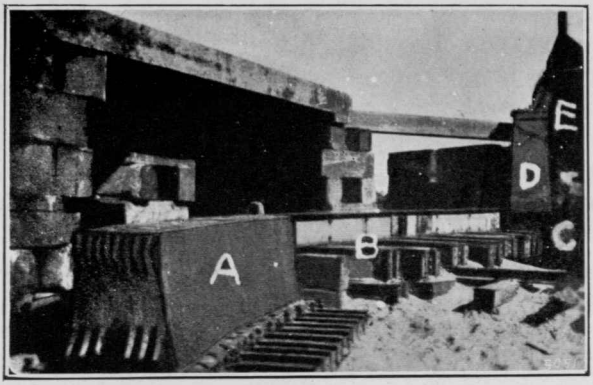


FIG. 1.

paratory to firing, thereby necessitating only a short hoist and greatly increasing the speed of loading. Ramps from the powder car and ground were also built. The ramps and platform made the work of the powder and rammer details much easier and quicker and made it possible to load readily with the gun traversed to any sector of the field

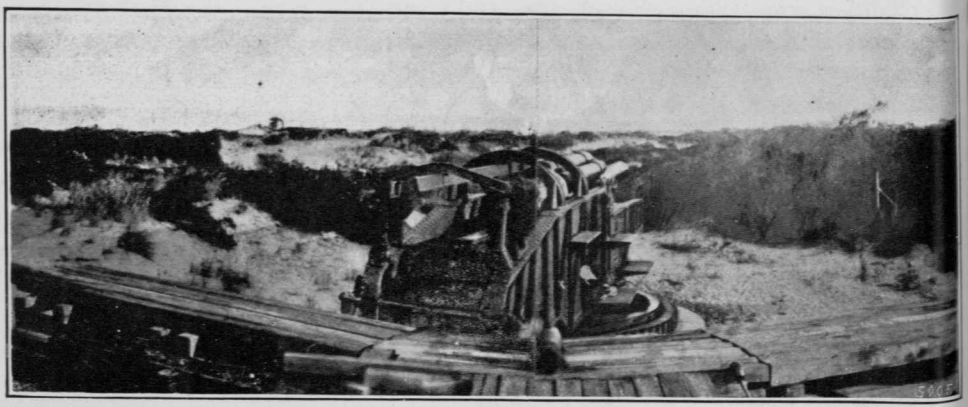


FIG. 2.

of fire. The platform is shown in Figures 2 and 3. A portion of the platform under construction is also shown in Figure 1. Devices were made for the measurement of the length of recoil and seating of the projectile. A powder tray by means of which all four sections of the

propelling charge could be loaded at once was constructed. The rammer stave furnished was apparently for a 10-inch gun and buckled badly under the strain of ramming. This difficulty was met by making a rammer stave of 1¼ inch iron pipe which was most satisfactory. The rammer and stave may be seen in Figure 3 lying alongside the ramp.

d. Communications. Telephone lines to the base end stations were installed by the battery personnel under the supervision of Master Sergeant Gee from Fort Monroe. It was necessary to string more than twenty-six miles of twisted pair. Two radio stations were installed and operated by personnel from Fort Monroe. One station, for communication with airplane, was placed in a room adjacent to the plotting room. The other, for communication with the towing vessel, Fort Monroe, and general utility, was a radio truck outfit located at Cape Henry Light.

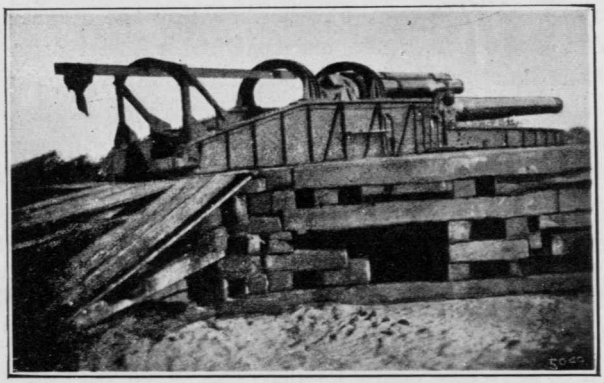


FIG. 3.

A time interval system was installed using a time interval clock to ring time interval bells at the gun position and in the plotting room. Headsets were hung so that the transmitters were in contact with the bell in the plotting room. These headsets were connected on the lines to the base end stations and thus carried the time interval signal to observers and readers as an audible click in their headsets.

e. Method arranged for determining deviations during the firing.

(1) The deviations to be used by the battery commander during firing were those to be reported by radio from the airplane observer using the clock code. (Note: this will be explained in detail in paragraph 5.)

(2) In order that the safety officer might know the actual deviations during firing it was arranged for base end and lateral observers to report the azimuth of each splash to the plotting room and for the deviations to be plotted on the 110° plotting board. The battery commander was not to use these deviations or even to know them. It was also arranged for photographs of the splashes to be made from the towing vessel.

4. *A description of any special mechanical devices used in the practice.* No special mechanical devices were used.

5. *A statement of any special methods employed during the practice.* The system of fire control employed was entirely new, based as it was entirely upon data received from the airplane observer. The method used was as follows:

a. Determination and transmission of data by the airplane observer. Maps, scale 1/80,000, bearing a 1,000 yard magnetic grid were furnished to the observer and the battery commander. The observer, having identified the target, called the battery radio station and reported the direction and speed of the target and the location with reference to the special map referred to above. The following is a typical message "ENE–5–5W", which means that the target is traveling East Northeast (magnetic compass bearing) at a speed of 5 knots per hour and is now in the center of the 1,000 yard square shown on the magnetic grid map as 5W. When the observer deemed it advisable he attempted to supply more accurate data by furnishing the bearing in degrees instead of in compass points, and by indicating the subdivision of the 1,000 yard square. (Each of the squares was quartered and the Northwest, Northeast, Southwest, and Southeast quarters designated as A, B, C, and D respectively.) A typical message of this sort was "N55E–5–5WC," which means that the target is traveling in a direction 55° East of North at a speed of 5 knots per hour and is now in the center of the Southwest quarter of square 5W. Deviations of impacts from the target were reported by the observer in the "Clock Code" which is explained as follows:

"The observer will report results by the Clock Code, the line 12 o'clock - 6 o'clock of the imaginary clock-face representing the bow-stern line of the target. 3 o'clock being due starboard and 9 o'clock due port of the center of the target. Radial distances of imaginary circles with the target as the center will be designated as follows:

Z	25 yards	FB	600 yards
A	50 "	FC	700 "
B	100 "	FD	800 "
C	200 "	FE	900 "
D	300 "	FF	1000 "
E	400 "	FG	1100 "
F	500 "	FH	1200 "

Rounds falling more than 1200 yards away from the center of the target will be reported by "FO" or "FS" followed by the distance in hundreds of yards as "FO 15," meaning over 1500 yards, or "FS 20," meaning short 2000 yards, etc., followed by the clock radial figure to indicate the direction, for example: "FO 154," meaning 1500 yards over in the direction of 4 o'clock, or "FS 2010," meaning 2000 yards short in the direction of 10 o'clock. * * * * *

Actual hits will be reported as "HIT."

Rounds unobserved will be reported as "UN."

Notification of guns having fired will be transmitted to the observer at the instant of shot by double repetition of the letter "F" from battery radio station.

When engaging a moving target the observer will radio his observation of the shot at the instant he sees the shot fall.

All observations will be twice repeated before the observer cuts over to receive signals.

Ground stations will acknowledge receipt of the observer's messages by the conventional form "R." Observers will then remain on receiving until "F" is again received."

(Note: the above is quoted from a paper by the Signal Officer, Langley Field, Va., on "Cooperation of Airplanes and Coast Artillery," dated September 22, 1922.

b. Procedure in the plotting room. The message telling direction, speed, and location of the target was received in the plotting room by a man who was called the "airplane message recorder." He was provided with a record book for recording all data received and transmitted by him, a table for converting knots per hour into yards per minute, and a stop watch for noting the time of receipt of position messages. His post was with the radio operator. Upon the receipt of a message showing the location of the target he noted the exact time of receipt as "Time No. 2 plus 16" (which means 16 seconds after Time No. 2), converted the knots per hour travel reported by the airplane into yards per minute and transmitted the data to the plotting board in the following form "5Q–N55E–185–Time 2 plus 16" which means that the target was, at 16 seconds after Time 2, in the center of square 5Q traveling in a direction 55° East of North at a rate of 185 yards per minute. On receipt of this data the plotter located the target in the center of the designated square, and, using a protractor of transparent celluloid graduated in compass bearings, laid off the direction of the course. In the meantime the assistant plotter, by means of a set-forward-ruler, determined the travel between Time 2 plus 16 and Time 3 and called out this travel to the plotter to enable him to locate on the course the position of the target at Time 3. The battery commander then decided at what time he would fire and ordered the plotter for example: "Fire at Time 6." The plotter then predicted ahead three minutes' travel on his course, and called out to the assistant plotter the time of flight. The assistant plotter, using the set-forward-ruler, determined the travel during the time of flight and gave this datum to the plotter who then located the set-forward-point on his course. At this point the arm-setter brought the gun arm up to the targ, which the plotter held at the set-forward-point, and called out the uncorrected azimuth; the plotter then called out the uncorrected range adding for what time number the firing data was computed. From this point the computation of firing data was done in the customary manner by the use of the atmosphere slide rule, wind component indicator, range correction board, and elevation deflection board. Elevation and deflection were transmitted to the gun by the elevation deflection board operator. The gun was fired on the bell. This procedure was followed each time that a new location

of the target was received from the airplane observer. After a shot had been fired the course was corrected by the amount of the reported deviation if the battery commander thought it advisable. This was done in the following manner. The airplane message recorder received the report of the deviation from the radio operator and transmitted it immediately to the plotter who changed the course on this basis when so directed by the battery commander. The normal method of changing the course was as follows: the plotter used a "deviation clock" (a piece of transparent celluloid marked with directions and radial circles in accordance with the Clock Code; see *a* above) and super-imposed the clock with the indicated deviation exactly over the plotted set-forward-point and the 12 o'clock–6 o'clock line parallel to the course; the center of the clock then indicated the corrected location for the set-forward-point. Another method of doing the same thing was to invert the clock, that is, point the 6 o'clock direction in the direction of the target's travel, place the center of the clock over the plotted set-forward-point, and then locate the corrected set-forward-point at the point on the clock indicated by the reported deviation. By either method the result was to move the set-forward-point by a distance equal to that of the reported deviation and in a direction opposite to that of the reported deviation. From this corrected location of the set-forward-point the plotter laid off another course parallel to the old one, unless otherwise directed by the battery commander, and predicted on that course from the corrected set-forward-point in a manner similar to that outlined above. It was realized that this method of procedure involved an erroneous assumption, namely, that the shot would in each case strike the set-forward-point at which it was aimed, and that the error introduced would be at least as great as the deviation of the shot in question from that set-forward-point. The case outlined above is the simplest one and was the method used when the reported deviations seemed to indicate that the course was approximately correct as far as speed and direction was concerned but not correctly located. I do not think it possible to lay down any definite procedure to be followed when it appears that speed or direction, or both, have been incorrectly reported. This is a question of the battery commander's judgment based on the evidence in hand. This matter will have some concrete illustrations in the discussion of the actual firing in paragraph 8. As a safety precaution, for the detection and prevention of dangerous errors which it was feared might escape notice under the new method, and for the collection of data for use in analysis the target was tracked and plotted by the horizontal base system. The plot was made on a large 110° plotting board. (This board was especially constructed, I was told, for experimental long range firing at Sandy Hook. It may be used for ranges up to 30,000 yards. The scale is 400 yards to the inch.) When the range and azimuth were called out by the plotter and arm-setter of the Whistler-

Hearn board (the one on which the airplane data was plotted) the assistant plotter of the 110° board set the gun arm to the azimuth called out and the plotter located this set-forward-point on his board. This enabled the safety officer to compare the location of the point to be fired at with the actual path of the target and to cause the battery commander to relay in case the location was such that the towing vessel might be endangered. Assistant safety officers were stationed at the secondary station and at the lateral observer's station near the battery. The azimuth of each set-forward-point from the secondary station was read on the 110° board and telephoned to the assistant safety officer in the secondary station, and in no case was fire ordered until "Field Clear" had been received from this officer. The officer in the lateral observers' station also received the azimuth of the set-forward-point and reported "Range Unsafe" in cases of danger to the towing vessel or passing ships.

The plotting room methods set forth above required no special equipment. For plotting the track of the target and determining uncorrected range and azimuth for firing data a Whistler-Hearn plotting board was used. All the arms but the primary were removed. This was used as the gun arm and gun azimuths were read on the main azimuth circle by means of the primary index box. In order to obtain sufficient range with ample allowance for corrections a scale of 1,000 yards to the inch was employed. It was felt that the inaccuracies due to using so small a scale would be of little account in a system of computing firing data on airplane observation as such a scale can readily be read to 25 yards while the error of the airplane data is likely to be greater than that. The only equipment that had to be made for use with the plotting board consisted of a prediction scale, and the compass bearing protractor and the deviation clock described above, all of which were readily made by the plotter himself. An elevation deflection board of the type that has for some time been in use in railway artillery batteries was constructed by the range officer, assisted by the plotter and the battery mechanic. On this board, operated by one man, the following operations were accomplished (1) wind and drift corrections introduced, (2) arbitrary correction introduced, (3) corrected azimuth converted into deflection, and (4) corrected range converted into elevation. All other equipment used was standard.

6. *A statement of the method of fire adjustment employed with the reasons for its adoption in preference to other methods.* No method that could properly be called one of fire adjustment was used. The method employed was rather one of adjusting or changing the position, speed, or direction of the target (or all three) until the reported deviations indicated that the conditions represented on the plotting board agreed very closely with those actually existing.

7. *A statement of the solution of the problem adopted by the battery*

commander. The solution adopted was to prepare to execute fire in accordance with the methods outlined in the preceding paragraphs using no position finding service but the airplane.

8. *A discussion of the application of the method of fire adjustment employed.* Instead of a discussion of fire adjustment this paragraph will deal with the application of the methods adopted to the two phases of the problem; first the firing at the hypothetical moving target, and second, the firing at an actual moving target.

a. FIRST PHASE: Firing at a hypothetical moving target indicated by a row of anchored targets, November 14, 1922. Average range 17,434.8 yards. The four trial shots fell short 755, short 540, over 538, and over 778, in the order named. The deflection deviations in degrees were .35, .32, .35, and .35, all left. (Two shots had been fired for test purposes on November 8th) and the data computed for these four shots had taken into account the muzzle velocity developed at that time.) Obviously these shots called for no range correction and a correction of right .25 was ordered in direction. (The lateral deviations as plotted at the time showed .25 as the mean deviation.)

First Course.

The message from the observer was "NE–12–5U." The target was located and its course plotted in accordance with this information. (See Figure 4 on insert herewith.) A set-forward-point was located on the course at the end of six minutes' travel plus the time of flight and firing data were computed for this point. The observer reported the shot as "FE–7," that is 900 yards from the target in the direction of 7 o'clock. The course was shifted by this amount with no change in direction or speed.

The set-forward-point for the second shot was located by a six minute prediction from the corrected location of set-forward-point No. 1. The shot was reported as "FD-9." This set-forward-point was relocated in a similar manner and a new prediction made. The same procedure was followed for the remaining two shots on this course. These were reported as "D–9" and "F–9," respectively. The same procedure was followed, shifting the course without changing direction or travel. Note that for this course the travel reported was very nearly correct, and that had the direction been correctly given the course would, after the relocation of the first set-forward-point, have been practically perfect.

Second Course.

The initial position was reported in the same way and predictions and changes made in the same manner until the reported fall of the sixth shot (the second on this course) caused me to suspect that the observer had reported a wrong direction of the course. My reason for thinking this was because the sixth shot had fallen short by practically the same

amount as the fifth. Examination of the course showed that an error in the direction of the course of 5° would be about enough virtually to neutralize the effect of having relocated set-forward-point No. 5. The direction of the course was therefore changed to N50E, a change of 5° to the right. On the seventh shot the gun pointer made an error of 10° in setting the deflection which resulted in a tremendous deviation. (It is interesting to observe that the airplane observer reported this deviation correctly.) Firing was stopped, but the cause of the deviation was quickly discovered, and another shot was fired on the data that had been intended for shot No. 7. On the basis of shot No. 8, the course was again shifted and direction and speed left unchanged. The chief point of interest about this course is the change of direction after the sixth shot. It must be admitted that the evidence on which this change was based was rather scanty, but, as it turned out, the change was a proper one though not quite large enough.

Third Course.

The initial data for this course were "ENE–15–5QD." Prediction was made and shot No. 10 was reported "FF–1." The set-forward-point was relocated in accordance with this report and a prediction made from that point. Shot No. 11 was reported "FF–2," practically the same relative position with respect to the target as shot No. 10. Shot No. 10 fell approximately 800 yards ahead of the target. Since correction for this lateral deviation was made by relocation of the set-forward-point, it was reasonable to expect that the lateral deviation of the next shot would be comparatively small because it was known that the gun shot accurately in direction. Therefore a lateral deviation of approximately 800 yards left on the 11th shot must be due to using too great a travel. Since my set-forward-point had gained 800 yards on the target in 6 minutes, the error in travel must have been approximately 800/6 or plus 133 yards. The travel was ordered reduced by that amount. I believe that this was sound reasoning and absolutely the proper precedure. For the same reason the course was retarded by 800 yards. Since the mean range deviation was approximately 500 yards over (for these two shots) the course was moved so as to reduce range by 500 yards. (As a matter of fact the mean deviation was more than 600, but a hasty determination at the time indicated 500.) A prediction was made from the point thus located and shot No. 12 was fired. This was reported "A–9" which meant short 50 yards and line. This was so close to the target that I did not consider that any change of the course was called for. The thirteenth shot was reported "F–4." The executive officer of the board considered that the results desired from this test had been obtained at the end of the third course, so "Close Practice" was ordered.

This test showed that the methods employed were practical, gave a

general idea of some of the difficulties and problems that might be encountered, and was particularly valuable as what might be called the "trial spin" of a new machine.

b. SECOND PHASE: Firing at a moving target. Average range 19,015 yards.

First Course, November 15, 1922.

The airplane checked into the battery radio station at 9.55 A M. The steamer *Schofield* was ordered to commence towing using a 2,000 yard towline. (The length of towline actually used was 1,770 yards.) The target had hardly gotten well under way when the towline parted which delayed the firing for over an hour.

When the target was again on its course the airplane observer sent an initial location message at Time No. 0. The message was "N55E–5–50C," that is the target was reported to be moving in a direction 55° East of North at a rate of 5 knots per hour, and at the time of the message was in the center of the Southwest quarter of square 50 on the magnetic grid map. For a better understanding of the situation refer to Figure 5 on insert herewith.

Based on the above initial location of the target a prediction was made and firing data computed for Time No. 5. This shot was reported "E–8" that is, 400 yards from the target in the direction of 8 o'clock. I made no change in the course on the basis of this shot because I felt that this deviation was as likely to be due to the dispersion of the piece as to an incorrect location of the set-forward-point. A glance at the plot, however, will show that had the set-forward-point been relocated on the basis of this shot the new location would have been quite near to the actual position of the target. No change was made as a result of the second shot, which was reported "AB–9" (short 150 and line) for the same reason that none was made after the first shot. After the third shot, reported "D–9" (short 300 and line), I thought that the deviations were small enough to indicate that the course determined by airplane was quite near to the actual course. Comparing the plots shows that this assumption was incorrect. My reasons for thinking this were that I had three successive deviations in range all of which might very well be due to dispersion rather to an incorrect location of the course. The lateral deviations reported were all so small as to indicate that the travel was very nearly correct. For these reasons I decided to assume that I had the course correctly located, and to attempt to bring the center of impact onto the target by means of arbitrary range corrections, in other words, to adjust fire by means of the adjustment slide rule method. The center of impact of the three shots fired was approximately 300 yards short of the target so a correction of plus 300 was ordered for the next shot, which was reported "C–11" (80 short and left). No change was made for the next shot which was ordered for Time No. 25. Exam-

ination of the plot indicates that too great a travel was being used, which caused the successive set-forward-points gradually to work ahead of the target, but not enough to be readily perceptible by means of the reported deviations. This error in travel caused the set-forward-point for Time No. 25 to be so far ahead of the target as to endanger the tug and caused the safety officer to order fire withheld. Another prediction was made for Time No. 28, with the same result. The safety officer then directed me to retard the course 1200 yards as a safety precaution. A prediction on this basis was made for Time No. 31. The shot was reported as "B–6." At this time the airplane was forced to land on account of engine trouble. A relief plane was sent out in the afternoon, but on account of weak batteries in the battery radio station it was impossible to establish communication with the airplane. No further firing was done on that date.

From a study of this firing I decided that it was unwise to attempt any actual adjustment of fire, as better results would probably have been obtained had efforts at correction been confined to changing and adjusting the course to get it as nearly correctly located as the limited evidence would permit. The gun or battery should be adjusted before fire by airplane is commenced.

Second Course, November 16, 1922

See Figure 6 on insert herewith.

The airplane checked in at 10.00 A M, and at 10.47 the target was on the course. As a result of the previous day's firing it was decided that it would be quite safe to use a 1,000 yard towline. The length of towline actually used was 1,100 yards. The first two messages received from the plane brought the set-forward-point too close to the *Schofield* to permit firing. Another location was received at Time No. 16½ plus 20, and a prediction made and a shot fired at Time No. 21, which was reported "FC8." The location of the set-forward-point was corrected in the usual way. It will be noted by referring to the plot, that the plotter made what was practically a constant error in the location of all set-forward-points from Shots Nos. 1 to 6 inclusive. It might, therefore, be assumed that the excellent results obtained on this course were due, in part, to accident as a result of this error. This is not so at all for, had the plotter made no error, the shots would then have fallen farther to the right by approximately the amount of the error which was to the left. It is safe to assume that the observer would then have reported the shots as further to the right and a corresponding change would then have been made in the relocation of set-forward-points, thus attaining the same results. I say that this is a safe assumption on account of the uniform excellence of the airplane observer's spotting. After the second shot travel was reduced to 135 yards per minute as a safety precaution. After the third the course was retarded 675 yards also by

direction of the safety officer. Had these changes not been made by the safety officer, changes of approximately the same amounts would undoubtedly have been made as a result of firing for the reasons explained above. The second and third shots were both reported fairly close to the target, "C–4" and "B–7," respectively, and no change was made in the course. The fourth was farther away, "FC–4," but I thought it better to wait one more shot before deciding whether a change of the course was necessary. Shots 5 and 6 were reported "B–4" and "Z–10" respectively, and obviously warranted no change.

At this time it was decided to call upon the plane for another location of the target in order to test again the practicability of the methods being used. The observer located the target in "6HA" at Time No. 1 plus 25, same direction and speed as before. (Note: after Time No. 60, Time numbers began again with No. 1.) A prediction was made and shot No. 7 was fired at Time No. 5. The fall was reported "F–10" and the set-forward-point relocated accordingly. After this shot the gun was out of order for twenty minutes due to loosening of the breech-plate. This made it necessary to make a twenty-four minute prediction and the next shot was fired at Time No. 29. It was reported "D–5," (300 yards from the target, over and right,) rather remarkable, considering the very long prediction. This concluded the practice, as it was decided that the results obtained had been satisfactory, and further firing at this time was impossible as the target had reached the end of the course and the airplane was nearly out of gas.

* * * * * *

10. *A general resumé of the practice to emphasize all points of interest.*

* * * * * *

b. The airplane observer. To me the work of the airplane observer was nothing short of remarkable. His estimates of direction and speed were surprisingly accurate; his locations were very close; and his spotting was uniformly excellent. He observed 26 shots of which he did not lose a single observation. Every shot was reported in the proper direction from the target, and while naturally there were errors in distance, none of these errors was great enough to mislead the battery commander. The observer for all three days was Captain F. N. Shumaker, A. S., Langley Field.

c. The plotting system was in the main satisfactory. There are several minor changes that might be made to advantage, but these are all matters of detail and undoubtedly would be done differently by different battery commanders. I believe that the methods employed were sound in principle. The results obtained indicate that they were practical.

11. *Conclusions.* As a result of this practice I have reached the following conclusions:

a. That air observation is preferable to ground observation when

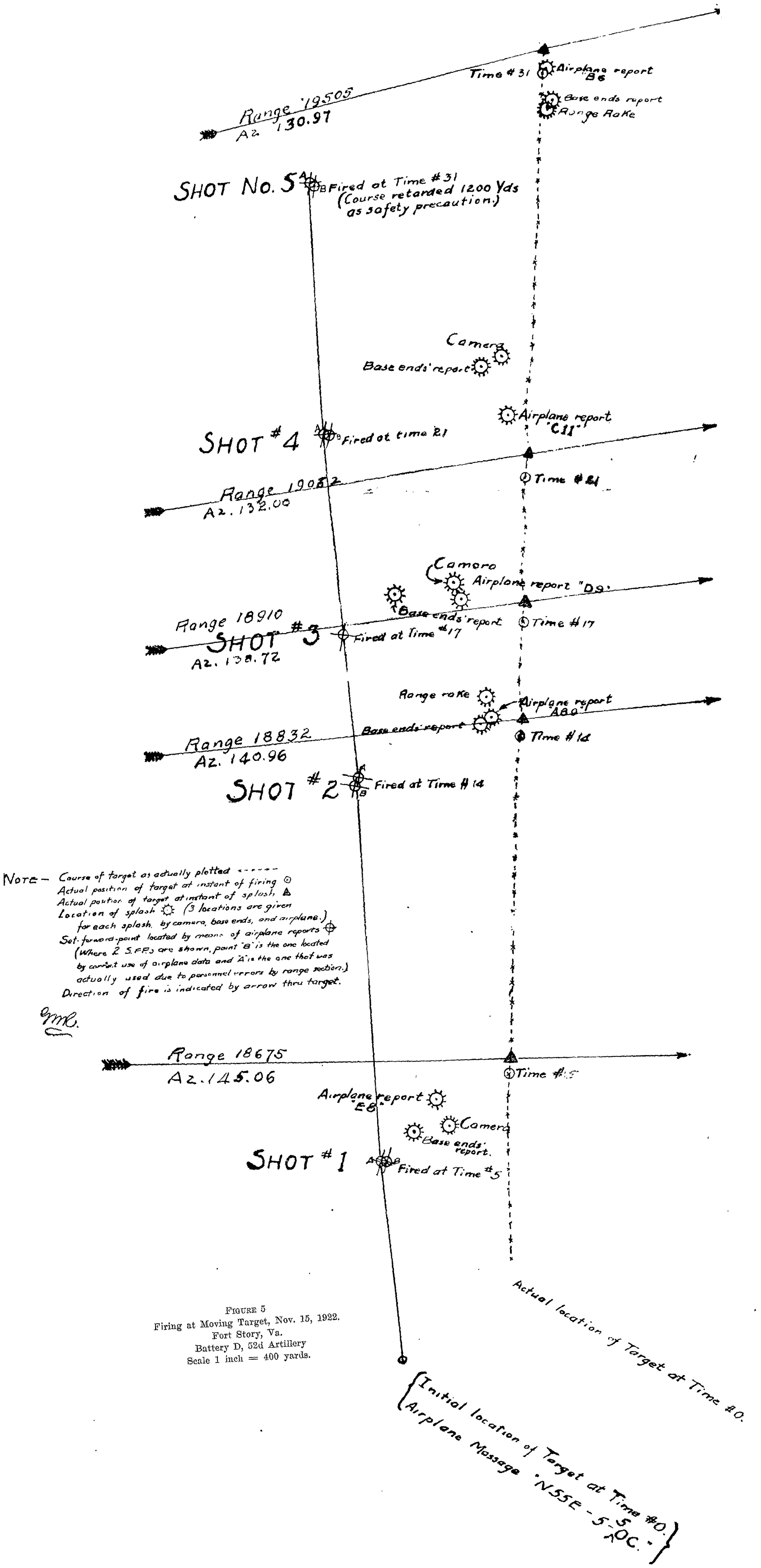


FIGURE 5
Firing at Moving Target, Nov. 15, 1922.
Fort Story, Va.
Battery D, 52d Artillery
Scale 1 inch = 400 yards.

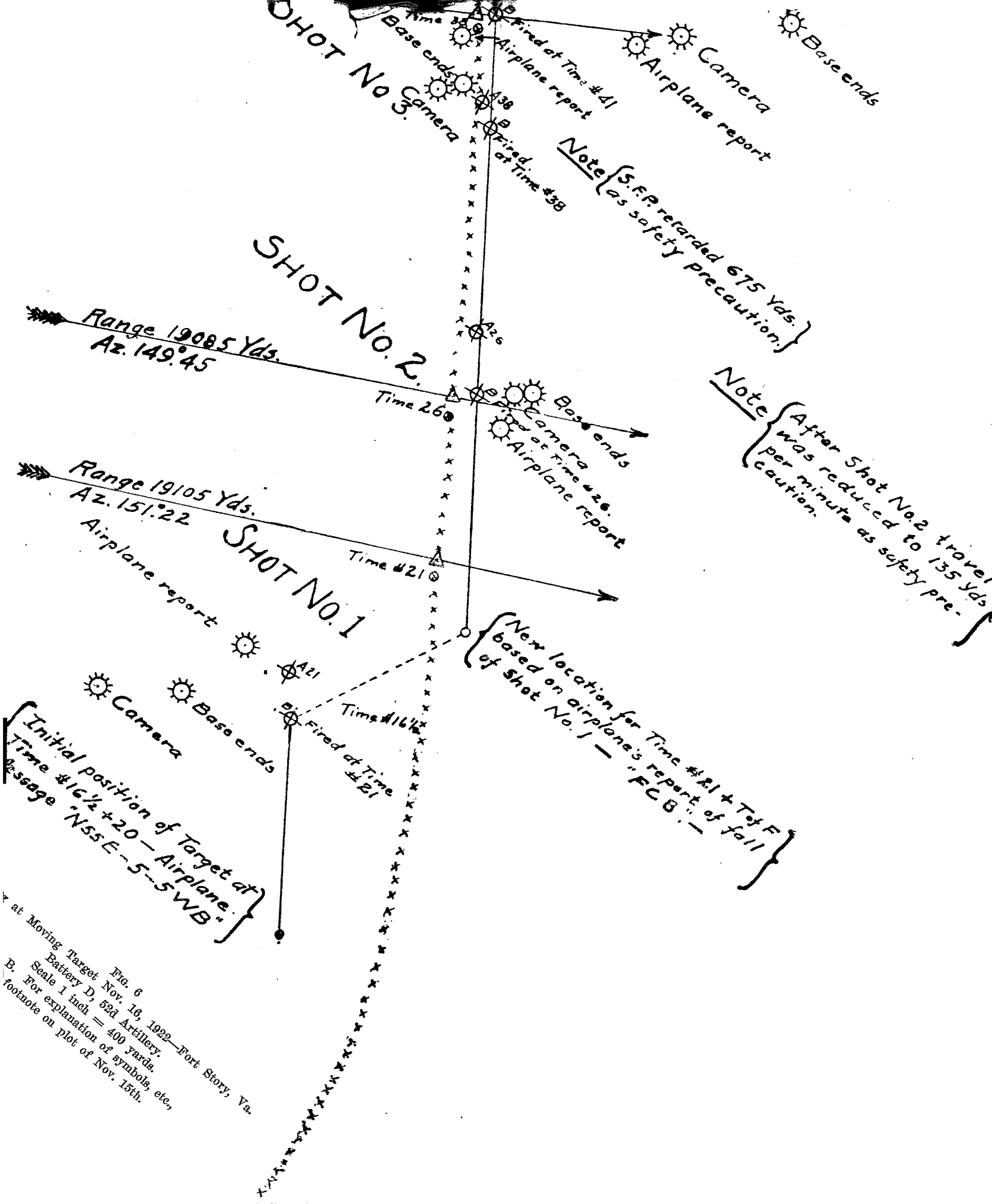
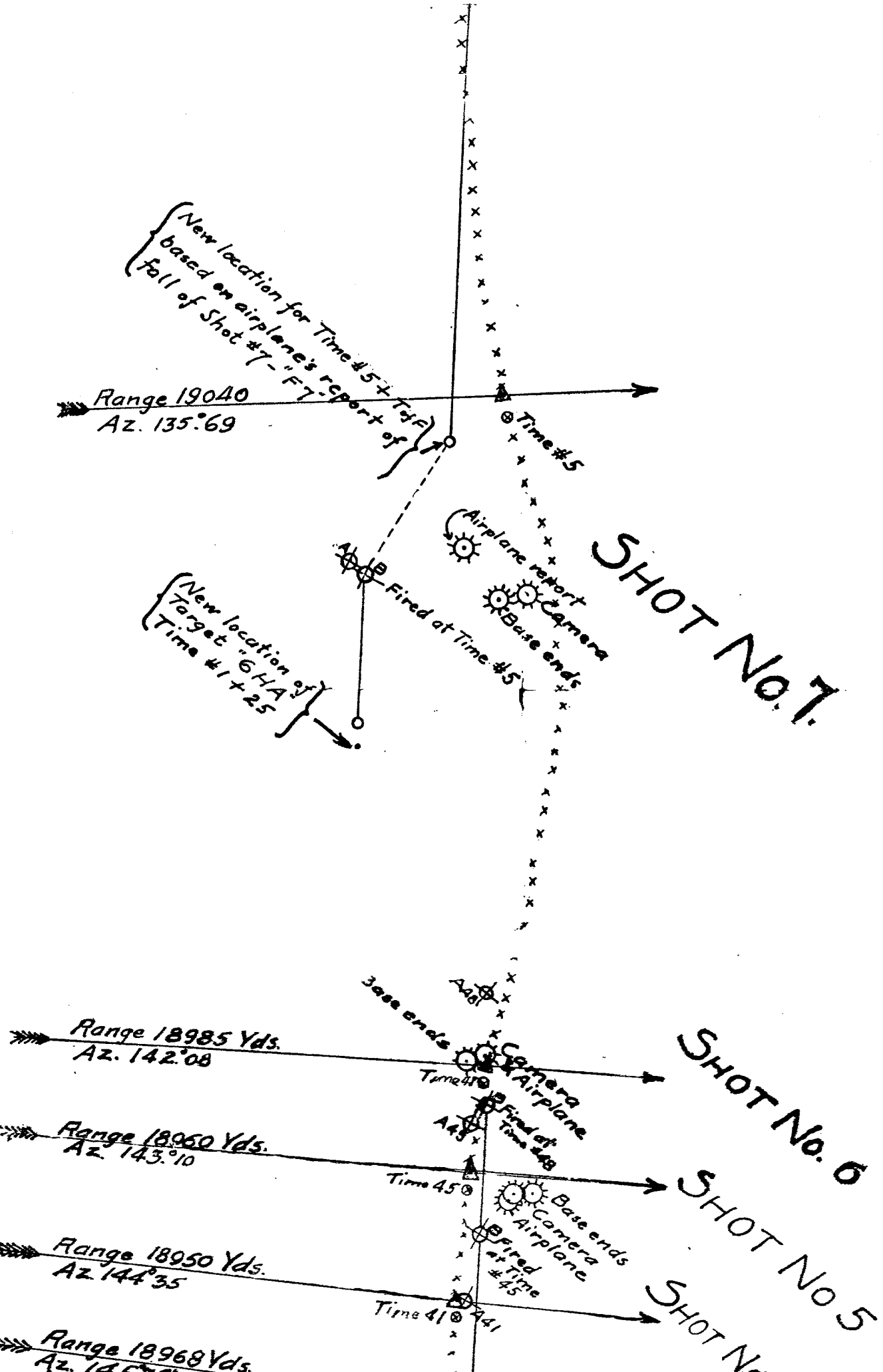


Fig. 6
at Moving Target Nov. 16, 1922—Fort Story, Va.
Battery D, 52d Artillery.
Scale 1 inch = 400 yards.
B. For explanation of symbols, etc., footnote on plot of Nov. 15th.


New location for Time #5 based on airplane's report of fall of Shot #7 - "F7"
Range 19040
Az. 135°.69
Time #5
Airplane report
Camera
Base ends
Fired at Time #5
New location of Target "6HA" Time #1 + 25
SHOT No. 7.
Base ends
Camera
Airplane
Time #6
Range 18985 Yds.
Az. 142°.08
SHOT No. 6
Fired at Time #6
Range 18960 Yds.
Az. 143°.10
Time 45
Base ends
Camera
Airplane
Fired at Time #45
Range 18950 Yds.
Az. 144°.35
Time 41
SHOT No 5
Range 18968 Yds.

for any reason the ground observation system is unable to function effectively. These reasons may be great range, poor visibility, target obscured from one of the ground stations, or ground observation system out of order from any cause.

b. That airplane control of fire at targets beyond visual range from shore is practicable and that good results can be obtained provided (1) that there is reliable two-way radio communication between airplane and battery, (2) that the guns of the battery are in a fairly good condition of fire adjustment, and (3) that the deviations are reported with a reasonable degree of accuracy. It is essential that the guns be adjusted and that the battery commander be well acquainted with their performance at the ranges to be used. It must be borne in mind that the battery commander is not sure of the location of the target. He does know accurately the location of each set-forward-point. If his guns are adjusted he knows that his center of impact will be very close to the set-forward-point. He will know with a reasonable degree of certainty, by means of the reported deviations, the relative location of each shot with respect to the target. With this knowledge and the additional knowledge of what deviations are to be expected as a result of dispersion he can adjust the plotted course so as to bring the ladder of dispersion to include the target. When the reported deviations indicate that this has been accomplished, no further changes of the course should be made except those necessary to maintain this condition.

Battery "A", 51st Artillery Fires G.P.F.'s at Moving Targets

Extracts from the Report of Captain Robert N. Mackin, C. A. C., with comments by Major Rodney H. Smith, C. A. C., the Regimental Commander

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I. *Statement of Problem:* The object of the practice was to determine the adaptability of the 155-mm gun for firing effectively at moving water targets as a rapid fire battery without addition of special equipment.

II. *Special Method of Training:* Because of the fact that a similar practice had not been held in the United States the entire training of the battery was specially developed for the practice. This special training was as follows: The drill of the piece for tractor artillery was modified to conform to the necessities of the practice. A gun pointer and an elevation setter were used to set the sight for deflection and elevation, point and lay the piece and to give the command for firing the piece. The gun pointer set the deflection on the micrometer scale of the sight and, by means of the traversing hand wheel, kept the vertical wire of the sight on the target, giving the command "No. — Fire" when the No. 1 had reported "READY." Traversing was not stopped during the loading of the piece.

The elevation setter set the elevation received on the elevation scale, kept the cross level bubble centered and the elevation level bubble centered at all times by means of the elevating hand wheel. Elevating or depressing the piece was not stopped during loading.

No. 1 opened and closed the breech and fired the piece from the left side of the gun (American block) at the command of the gun pointer. When the piece was fired No. 1 only partially rotated the firing mechanism block, then opened the breech and completed rotation and removal of the firing mechanism block after the breech block had been caught and held open by the back latch catch. He then handed the firing mechanism block containing the fired primer to No. 4. The breechblock was closed with the firing mechanism block partially rotated and rotation was completed when the breechblock was fully closed.

No. 2 assisted No. 3 in ramming and inserted the powder charge. No. 3 rammed the projectile and sponged the chamber after firing. No. 4 measured the setting of the replenisher piston after every other

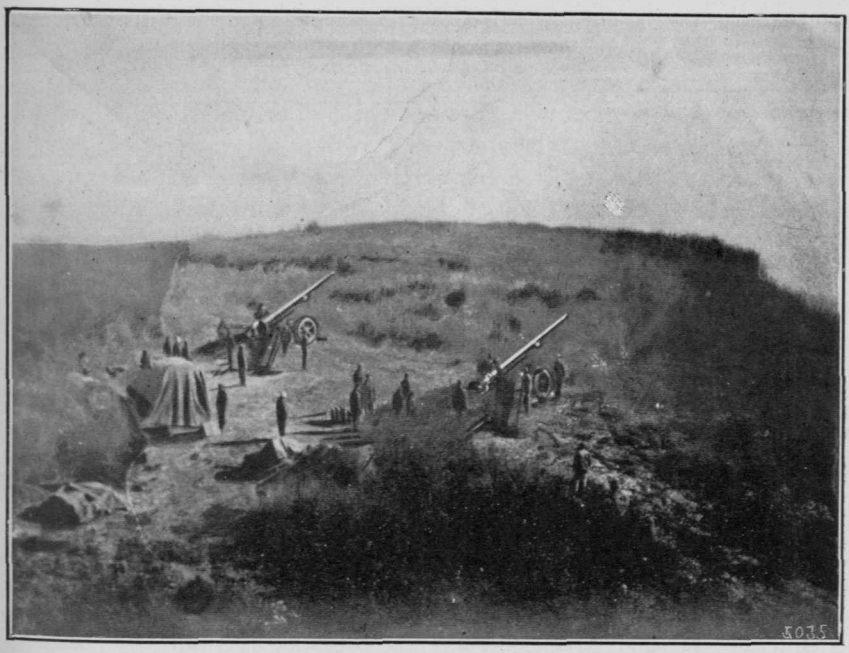
shot, calling the setting to the gun commander. He also received the firing mechanism block from No. 1 and handed him a clean firing mechanism block with a fresh primer in place.

No. 5 acted as a powder runner between the powder pit and No. 2.

Nos. 6 and 7 carried the loading tray and inserted it in the breech. After the shell had been pushed off the tray No. 7 stepped back and took his post. No. 6 removed the tray and returned it to its stand.

No. 8 inserted the fused projectile on the loading tray.

No. 9 handed powder charge to No. 5.



BATTERY POSITION BATTERY "A," FIFTY-FIRST ARTILLERY NEAR TOWER 5, CAMP EUSTIS, VA.

Nos. 10 and 11 opened powder cases and prepared powder for issue.

A non-commissioned officer was selected and taught the use of the range finder. This operator gave not less than two thousand readings at 30 second intervals before the practice, being checked often by the battery commander.

A non-commissioned officer was selected as battery commander's observer and trained in determining the angular travel of the target during time of flight; the indication and identification of targets; and given verbal instructions in observing deflection errors.

Three telephonists were trained as recorders. Two men were trained to record the last elevation and deflection sent to the guns. This required quick work using clearly legible figures.

III. *Training of the Gun Crews:* Seventeen of the twenty-eight men available for gun crews, including the two gun pointers, had never been on a 155-mm. gun crew.

The crews were formed with the various men in their different positions, selections being made by the Battery Commander according to the apparent physical and mental qualities of the individual. Before any drilling was done the men were told that a minimum loading and firing speed of three rounds per minute must be obtained—(one round per minute being the normal rate of fire for tractor artillery).

Each man was personally instructed in his duties by the battery commander, and suggestions for the improvement of the drill were invited. The objective was attained the third day of drill in about 8 drill hours.

A great deal of care was taken in the training of the gun pointers and elevation setters. Their work was checked repeatedly, several changes being made until the right men were obtained. Several tests were made to determine keenness of eyesight and coolness under stress such as a change in elevation when the gun pointer had called No. — and before he had called "FIRE." Obviously erroneous elevations were given to observe the mental reaction of the elevation setters.

Frequent rests were given the entire battery but particular alertness was required during drill.

The battery position was eight and one half miles from the barracks over a very bad road. Care was taken that the noonday meal was hot and a little above the average in quality.

IV. *Preparations Made for Firing, Including Measures taken to insure Uniformity in Functioning of Matériel and to Determine the Deviations During Firing:*

Oct. 19th: A convoy of three tractors, two guns and three trucks carrying equipment and personnel left the 51st Artillery gun park at 10.30 a.m. Convoy arrived at battery position at 1.50 p.m., after an hour and one half halt for lunch and attaching wheel shoes. Position somewhat difficult to occupy. Guns nearly ready to fire at 4.30 p.m., when work was stopped for the day.

Oct. 20th: Guns ready at 9.30 a.m., after one half hours work. The rest of the morning was spent in refinement of the position, constructing powder shelters, installation of telephone line to spotting station and connecting with the meteorological station. The afternoon was devoted to the instruction of gun crews and Battery Commanders' observer.

Oct 23rd: The field of fire was divided into six sectors for indication of target. A nine-foot Barr and Stroud Rangefinder was installed on the left flank of the battery and oriented for direction and range. A telephone line was installed from the rangefinder to the B-C station. An F.W.D. truck was run into position between, and slightly in rear of,

the two guns and used as the B-C station. Eighty-eight empty projectiles were brought to the battery and sand-filled to weigh 95 lbs. They were then fused.

Oct. 24th: A complete battery drill was held for three hours this date, the targets being passing vessels.

Oct. 25th: This day a target towed by a U. S. Army L. boat was used for tracking, but the 10′ x 24′ target was invisible from the guns at ranges of over 5000 yards.

Oct. 26th: The morning was employed in reconstructing the target to improve visibility, a strip of red cloth six feet wide and ten feet high was placed in the center of the target and the structure was reenforced throughout. Size of target (10x24) was not increased.

In the afternoon this target was towed on the course but the target was still very difficult to follow.

Oct. 27th: The morning was spent in placing a 6 foot strip of white cloth across the width of the target at the top and another 10′ x 24′ target was reconstructed in a similar manner except that the white cloth was placed over the entire surface of the target with the addition of a 6 foot strip of red cloth down the center. Size of target (10x24) was not increased.

Oct. 30th: The target was found to be satisfactory and the day was spent in drill and instruction for calibration firing.

Oct. 31st: Ten salvos with a salvo interval of one minute, (reduced after the 10th shot to 30 seconds), were fired for calibrating the two guns and also for obtaining a muzzle velocity correction.

Measures taken to insure proper functioning of matériel and increase rapidity, accuracy and safety of firing: The coincidence rangefinder was checked on four datum points each morning and afternoon of drill, two of these datum points were at approximately the range at which service practice was expected. The ground about and in front of the guns was thoroly wet down to prevent obscuration of the target from either gun by dust. If one of the two guns misfired it was arranged that three minutes would elapse before a new firing mechanism block was inserted. In the meantime the other gun was to finish its share of the series and if this was completed before the first gun got into action the second gun would fire the remainder of the other's respective number of rounds. This was all under the supervision of the executive officer, the battery commander only giving the initial commands for firing. Elevation scales were tested at mid-range against a quadrant and the correction for each gun applied on the site correction scale. Recoil and recuperator cylinders were filled to the proper amount, care being taken that no air remained in the cylinders. The normal setting of the replenisher piston is 150-mm. However to avoid draining oil during firing and thereby possibly cause a delay, the recoil cylinders were filled to a setting of the replenisher piston of 175-mm, making allowance for the

expansion of the oil during firing. Bleeding was ordered when a setting of 135 mm. should be reached. The gun may be fired safely at settings of the piston between 100 and 200 mm.

The breech blocks were disassembled and thoroly cleaned, care was taken during the calibration firing to observe the closure of the blocks. The safety device on the face of the breechblock was tested. All firing mechanism blocks were very carefully gone over and new firing pins used. Where the primer retaining lip of the block was worn it was machined or not used if it could not be repaired.

The breech counterpoise was adjusted. The head of the sponge was wrapped securely with cloth so that the sponge would bear on the entire surface of the powder chamber.

The loading tray was modified to permit the rammer stave to pass through the top of the cylindrical portion of the tray. With this modification the tray could be taken from the breech recess, dropped down to permit the stave to come through and carried to the rear instead of the usual methods of leaving the tray in place until the projectile was rammed or sliding the tray along the stave before ramming. This modification caused a time saving of one and one-half to two seconds.

Fifty primers were each actually inserted in each gun as for firing to prevent any delay due to sticking of the case of the primer in the primer seat. All these primers were carefully examined for moisture or defects in manufacture.

All projectiles were cleaned and filled with sand and brought to a weight of 95 pounds. It was necessary to use sand-filled shells because a War Department order requires the taking of cover when high explosive shells are fired.

To avoid the placing of a powder charge in the gun with the igniting charge foremost the cans were placed in the pit with the igniting charge of the charge to the rear and the charge was carried and served in the same manner, the powder serving detail carrying the charge with the igniting charge in the palm of the right hand so that the soft pad could be felt in the hand.

Two backward and two forward strokes were used in sponging the chamber. Projectiles were fused before firing, the ground around the breech was covered with mats at No. 1 gun and brick at No. 2 gun to prevent the crew from slipping on muddy ground.

Measures taken to determine the deviations during firing: An officer and two range rake operators were placed on the vessel towing the target to observe and record the longitudinal deviation of each shot. Two lateral observers were placed at the battery to observe the lateral deviation of each shot.

V. *Special Mechanical Devices:*

The only device of any kind used in the practice which was not a regular part of the equipment of tractor artillery was the coincidence

rangefinder. The loading tray was modified as stated above to permit greater rapidity of firing.

VI. *Special Methods Employed:* Under this heading might properly come a detailed description of the method of obtaining, and correcting firing data and its transmission in the form of firing elevations and deflections to the guns; the control of fire and, in short, the method by which the battery was fired.

The rangefinder was installed 200 feet to the left of the battery, on a line with it and at the same level. Telephone communication with the B-C station was installed. The telephone operator was provided with a stop watch and called "TAKE" every 30 seconds and the range "TAKEN" sent to the B-C station over the telephone.

In the B-C station a B-C instrument was set up. Three blackboards of appropriate size were installed at the B-C, one clearly visible from the gun pointers upon which the last deflection and elevation for each gun was recorded. This board was used for reference by the gun pointers in case there was the least doubt about the data called by the battery commander. The other two boards were for the use of the Battery Commander both being close to his post and clearly visible to him. On one of these boards was recorded the last elevation and deflection sent to the guns, the other bore the last two ranges from the range finder.

A telephone to the camp meteorological station and one at the spotting station ran into the B-C station in addition to the telephone from the rangefinder. One assistant to the B-C observer with a stop watch, and a plane table containing a range table, firing data sheets, and a megaphone, completed the installation of the B-C station.

Sequence of events in firing the battery: A meteorological message was received hourly and from this was computed Wx and Wy, the bearing of the target used being that point at which the target would enter the field of fire.

The atmosphere correction was obtained in terms of variation from the normal of the weight of a liter of air in milligrams.

The powder temperature was obtained 10 minutes before firing and the correction therefore determined in terms of the number of meters per second change in muzzle velocity.

The muzzle velocity correction from calibration firing was at hand in terms of the number of meters per second change in muzzle velocity.

As soon as the target appeared it was indicated, following the methods described in C. A. D. R., and when the guns, rangefinder and the B-C observer had reported "ON TARGET," tracking was commenced.

The battery commander then awaited the command to commence firing. When this command was received the battery commander glanced at the last two ranges obtained from the rangefinder, added the amount of range change to the last range, glanced at the range table

and called out the time of flight in seconds for that range (A). The B-C observer called "NOW" and followed the target with the upper scale of the instrument. When the time of flight had elapsed the assistant called "HALT"; the B-C observer then read and called out the angular travel in mils during the time of flight, "RIGHT (so much)" if the target was going from left to right and vice versa.

After calling the time of flight the battery commander then entered the correction for wind and drift on his form as obtained from range table at range (A). He then computed the range correction for wind, atmosphere, powder velocity, and muzzle velocity, added them algebraically and applied resultant correction to range (A). With this range (B) he entered the range table, obtained the elevation and called it to the guns. If a new range had been received since range (A) was obtained, which contained a range change, the proper number of mils corresponding to this change in range was added to, or subtracted from the elevation sent to the guns.

The angular travel was added algebraically to the correction for wind and drift and the resultant deflection was called to the guns. The command for firing was then given as "One Salvo," "Commence firing." The guns were loaded and fired without further command. If a new range involving a range change was received at the B-C at any instant before the pieces were actually fired, the number of mils corresponding to the increase or decrease in range was added to or subtracted from the last elevation and this new elevation was called to the guns by the battery commander, he having before him on the board the last elevation set on the guns. From now until the end of the practice the guns were always kept laid in deflection and elevation.

When the guns were fired, the battery commander entered on his form the range and elevation at which the guns were fired. The B-C observer called the observed error for each gun and the battery commander glancing at the board mentally corrected the last deflection for each gun and called it to the guns. The range observer or spotter called or telephoned the overs and shorts of the salvo. From the range blackboard the battery commander noted the range change from the range as shown on his form, added algebraically the number of mils for this range change with the number of mils change necessary to carry out the adjustment, added to or subtracted this algebraic result from the elevation shown on his form for the last salvo and gave the new elevation and commands for firing. This procedure was carried out until the adjustment was secured.

If the ranges from the rangefinder showed no change in range of the target, any range change allowed was deducted from, or added to the elevation. Three ranges showing no change were considered sufficient basis for this action. If the target changed direction in range, a corresponding change in prediction for range change was made.

VII. *Method of Fire Adjustment used with Reasons for its Adoption in Preference to Other Methods:* The method used was the bracketing method as specified in Coast Artillery Memorandum No. 4, 1922, for rapid fire batteries.

* * * * * *

XI. *A General Resumé and Notes on the Practice:* (a) Throughout the preparation for the practice it was continually borne in mind that it was desired to fire a successful rapid fire practice at moving water targets with the 155-mm. gun using only the personnel now regularly assigned to and the matériel now issued to a battery of 155-mm guns in tractor artillery.

(b) The radio phone from shore to tug and vice versa worked excellently before, during and after the practice.

(c) There being no provision in tractor artillery for a battery range section no computer was used to determine for the battery commander the proper elevation at all times for the last range received, which could have been done by using extra personnel. This operation was performed by the battery commander without the slightest difficulty and since the 13 minutes of firing includes ten computations of data it will be seen that rapidity of firing was not interfered with.

(d) The above paragraph also partially explains the elimination of a device similar to the time range relation board. With a probable error of 58 yards, and a 100% zone of 464 yards and considering the rate of fire and the method of adjustment it was not thought that a maximum possible time range error of 29 seconds justified a divergence from the plan as outlined in paragraph (a). For obvious reasons a time-interval bell system was not used.

(e) One of the observing stations of the horizontal base system which was to have plotted the course of the target for analysis was unable because of haze to see the target and no plot was made. This makes impossible the correct plotting of each shot on cross section paper.

(f) The battery commander had to be very familiar with the range table. Many features of it were memorized such as the value in yards of one mil of elevation at 7,000, 8,000, 9,000 and 10,000 yards. In correcting for observed lateral errors the battery commander endeavored to train himself to give new deflection instantly and not to stop to think which way it was necessary to move to correct for the error.

(g) Since the range table was graduated in meters and the range-finder gave ranges in yards it was necessary to add a range column in yards to the range table.

(h) The area covered by the guns of the battery was 70 degrees or 1244 mils.

(i) The guns were emplaced on an old Confederate fortification in a marsh near Tower No. 5, Camp Eustis, Va. The muzzles of the guns

being over the water at high tide. A tractor with capstan was run out in the marsh in front of the guns and used in pulling them into position. The gun platforms were five feet above sea level.

(j) The spotting station used was Tower No. 5, which was 110 feet high. This tower was 200 feet to the rear of the battery.

(k) A megaphone was used by the spotter when calling his observations, this it was thought saved a little time which would be taken up by repetition to and by the telephone operators.

(l) The battery installation needed no augmentation to handle four or six guns. While some doubt was felt as to the accuracy of the coincidence rangefinder with such a short base at the ranges used in the practice, it is significant to note that the first salvo was within one fork of the target and the last salvo results tend to show that the range change as given by the rangefinder were fairly reliable.

(m) No subcalibre practice was held because no subcalibre tube or similar device is supplied with the gun and the gun pointers followed the target, fired on it, got on target again while the gun was being loaded for the first time in the actual practice itself.

(n) The remarkable shooting together of the two guns after the calibration correction had been applied is worth noting and it is believed certainly justifies using both guns in trial fire.

(o) It was not necessary to drain oil during firing.

(p) The guns were withdrawn from position and returned to the battery gun park, eight and one half miles away, in two hours and thirty minutes.

(q) In the light of the experience obtained in this practice it is of interest to note that since no orientation and no long telephone lines are needed a tractor battery of 155-mm guns can occupy a position and be ready to fire at moving targets in much less time than is required for firing on land targets.

XII. *Officers on Duty with the Battery during Practice:*

Captain Robert N. Mackin, Jr., C. A. C.
1st Lieut. A. L. Bullard, C. A. C.

COMMENTS OF THE REGIMENTAL COMMANDER

1. In forwarding this report there are several items of interest to which attention should be called.

a. First, so far as known, this is the first time that G.P.F. 155-mm. guns have been used as a rapid fire battery against moving targets on the water. There was considerable doubt as to whether this gun could be so used efficiently. It was uncertain whether the matériel was adaptable for direct fire at a moving target at any range commensurate with the power of the guns, because said matériel was de-

signed purely and simply for use against fixed land targets, using indirect fire. There was skepticism concerning the adequacy of the sight, not only as an optical instrument but as an efficient device for a gun pointer to use in following a moving target.

b. Next there was doubt expressed as to whether the gun could be fired with sufficient speed against a mobile target to qualify as a rapid fire weapon. Could the gun be loaded and laid efficiently and rapidly while the pointer was following the target? These guns have not previously been fired during a target practice at a speed greater than one salvo per minute.

c. The next question was, granting that the matériel proved effective, would it be possible within any reasonable time and without sub-caliber practice to train efficient gun crews from tractor artillerymen who had had no previous experience in work against moving water targets with any gun?

d. Could computations be made and used with sufficient rapidity and accuracy to take care of range changes, without the addition of extra devices and personnel which would be superfluous in the field against land targets?

e. To sum up, could the Coast Artillery take this gun without modification of matériel and make an effective coast defense weapon thereof on short notice?

2. The answer to all these questions is contained in the very full and excellent report of the battery commander herewith, who is especially commended for his efficiency, energy, and initiative. It is a most emphatic affirmative.

3. I wish to especially stress the following points:—

a. The period of training was actually only 8 working days using a drill differing radically from that in use against fixed targets.

b. The corrected time for the 36 shots including bracketing, and improvement fire was 13 minutes and 12 seconds. During improvement fire a speed was attained of better than 3 salvos per minute, and this rate can be maintained or bettered during fire for effect.

c. The range varied from 8,800 to 9,600 yards and back again to 9,150 yards, giving a searching test of rapidity and accuracy of range computation. Speed of target 8 miles per hour.

d. The work of the gun pointers was excellent. All shots would have been hits for direction on an appropriate battle target such as a destroyer. No less than 30 shots were within 5 mils of the target, and 10 shots were absolute line hits, and this in spite of a heavy autumnal haze which so reduced visibility, that the horizontal base line which was to track for analysis purposes could not see the target.

e. The average range of firing was 9,288 yards, which made of the 10′ by 24′ target a mere aiming point. It was necessary to use the reduced charge to give all shots an angle of fall of 20° or greater to

avoid ricochets into the opposite shore of the James River. This gave an average range table danger space of 9 yards and a probable error of 58 yards. Actually conditions were more unfavorable than this as the powder used developed an M.V. of only 1825 foot seconds instead of the 1949 f.s. shown by the range table.

f. The course, the only one available because of adverse local conditions, was unsatisfactory and unsafe because of the multitude of small fishing boats which it was impossible to warn off although a safety boat was sent out for the purpose. In consequence four interruptions were necessary which would not have existed under battle conditions.

g. In spite of these difficulties, the remarkable record of 4 actual hits on the small material target was made during the improvement fire of 28 shots, and three others of the 28 missed the target by a matter of a few feet only.

4. Conclusion: This practice is an eloquent testimonial of the efficiency and adaptability of the matériel and personnel against a moving target on the water, i.e., for Coast Defense purposes.

(Sgd.) RODNEY H. SMITH,
Major, C. A. C.,
Commanding.

An Emergency Method of Fire Control for Anti-Aircraft Artillery

By Captain Dale D. Hinman, C. A. C., and
Captain Maurice Morgan, C. A. C.

IT is believed that Anti-Aircraft Artillery, like all other forms of artillery, requires an emergency method of fire control. Up to the present time no uniform emergency method has been prescribed and in the event of the destruction, damage or separation of fire control instruments from the guns, the Battery Commander's only resort would be a personal estimation of all the elements of data required by his battery. To those familiar with Anti-Aircraft Artillery the difficulties of making such estimations within the brief period available and within the approximate accuracy required are readily apparent and it is believed that the employment of the chart shown in Figure 1 offers a solution of the problem of emergency firing.

In order to deliver fire, Anti-Aircraft Artillery requires three elements of data: (1) Fuse Range, (2) Vertical Deflection and (3) Lateral Deflection. Any emergency method proposed must give quickly and accurately these values and, due to the fact that our largest error usually arises from an erroneous assumption in the matter of altitude, must also give the Battery Commander his Fuse Range, Vertical and Lateral Deflections for other altitudes in order that he may bracket his target and determine the correct altitude more or less accurately by the fire of his battery. The chart shown in Figure 1 is adapted to the requirements as outlined above.

CONSTRUCTION OF CHART

Angle of approach lines were drawn and appropriately labeled for every fifteen (15) degrees in azimuth; concentric circles with suitable radial lengths were drawn around "position of Plane" as a center and labeled with angular heights of 75, 60, 45, 30 and 15 degrees respectively. At the intersection of the various angle of approach lines and angular height circles boxes were constructed for the tabulation of the computed values of Fuse Range, Vertical and Lateral Deflections. Columns were provided for altitudes varying by 1000 yards for altitudes from 1000 to 5000 yards. The tabulated values were calculated and are correct to the nearest five mils, i.e., for an engine speed of 110 miles per hour. Elsewhere in this discussion it will be shown that the chart

can be used for engine speeds of ±15 miles per hour (i.e., between 95 and 125 miles per hour) by the application of a few simple rules. The chart was constructed for the 3-inch Trailer Mount, M. V. 2409 and for an engine speed (plane) of 110 miles per hour. A Dead Time of Maneuver of eight seconds was used in determining the various Fuse Ranges.

PRACTICAL OPERATION

The Battery Commander standing at the position marked "Position of Battery Commander and Guns" (Fig. 1) designates the target to the several pieces of the battery. The angle of approach of the plane shown in Fig. 1 is "Passing +90. One or more of the Gun Pointers (being on the target) may then read and announce the angular height to the Battery Commander. The Battery Commander makes an estimate of the angle of approach of the target and its altitude. Knowing the angular height, the Battery Commander enters the chart with angular height and estimated altitude and angle of approach as arguments and takes from the box at the appropriate intersection the Fuse Range, Vertical and Lateral Deflections to employ in firing the pieces. In the case of targets whose estimated speed was greater or less than 110 miles per hour the tabular values could be modified by the application of the rules discussed elsewhere in this paper.

Examples:	*No. 1*	*No. 2*	*No. 3*
Angle of approach	going +45°	going −0	Passing +90
Angular Height	45°	30°	60°
Altitude	3000 Yds.	2000 Yds.	4000 Yds.
Fuse Range	14.0	14.8	12.8
Vertical Deflection	280.	270.	300.
Lateral Deflection	350.	300.	400.

Obviously the largest error in the estimations required would normally be in the matter of altitude and the following procedure is suggested in handling this element of the data. Assume that shots were fired upon the estimations and consequent data above indicated in Example No. 1 and that the bursts were observed to be low. The Battery Commander would at once shift to altitude 4000 and fire a burst with appropriate data taken from the 4000 column. If these bursts were observed to be high (or over) he would employ a mean altitude and fire the third series with data hastily interpolated between the values given for 3000 and 4000 yards altitude. In the above problem his shots would have been fired with the following data:

	1st Series	*2nd Series*	*3rd Series*
F.R.	14.0	18.6	16.3
M.D.	280.0	275.0	277.5
L.D.	350.0	360.0	355.0

An experienced battery commander should certainly be able to estimate the altitude of his target within 1000 yards and his first and second series would normally establish an altitude bracket. If, however, his second series proved to be "low," he would fire on data for 5000 yards altitude and his fourth series would then correspond to the third series shown above and his data would be procured in the manner above outlined. In this connection it will be noticed that the vertical and lateral deflections for the various series are not materially different and it would be sufficiently accurate (for emergency chart firing) to use the same Vertical and Lateral deflections for all series and interpolate only for the correct value for Fuse Range since this element shows material variation for different altitudes.

The chart shown in Figure 1 was constructed for engine speed of 110 miles per hour but similar elements of data were calculated employing engine speeds of 100 and 120 miles per hour. The rules given below are the result of these calculations and it was further established that the rules are applicable to engine speeds ranging from 95 to 125 miles per hour, the error in Vertical and Lateral Deflections being less than five mils and the error in Fuse Range less than two tenths of one Fuse Range number.

From computed values the following rules may be laid down for use in the practical operation of the chart:

Fuse Range

A.—For Engine Speed of +10 or 120 Miles per Hour.

1. For Targets Passing 90 or Going 75 no correction need be applied.
2. For Targets Going 60, 45, 30, 15 and Going 0, add two tenths (0.2) of a corrector division to the chart value if targets are at an altitude of 3000 yards or greater. No correction for lesser altitudes.
3. For Targets Coming 75 no correction need be applied.
4. For Targets Coming at the angles of approach and altitudes indicated in (2) above, subtract two tenths (0.2) of a corrector division from the chart value.

B.—For Engine Speed of −10 or 100 Miles per Hour.

1. Rules are identical with those given under A but wherever corrections are prescribed they will be applied in opposite sign (minus for plus and vice versa).

Vertical Deflection

1. Engine Speeds of + or − 10 Miles per Hour (120 or 100) do not effect vertical Deflections to an extent sufficient to warrant correction and chart values should be used as given.

LATERAL DEFLECTION

A.—For Engine Speed of +10 or 120 Miles per Hour.

1. For Targets Passing +90 and Coming or Going +75, add 10 mils to the chart values.
2. For Targets Coming and Going +60, +45, +30, +15, add 5 mils to the chart values.
3. For Targets Coming and Going 0, no correction need be made.
4. For Targets Passing −90 and Coming or Going −75, subtract 10 mils from the chart values.
5. For Targets Coming or Going −60, −45, −30 and −15, subtract 5 mils from the chart values.

B.—For Engine Speed of −10 or 100 Miles per Hour.

1. Rules are identical with those given under A above but wherever corrections are prescribed they will be applied in the opposite sign (minus for plus and vice versa).

To illustrate the use of chart and correction rules a number of problems and answers have been tabulated in the following form. Appropriate columns indicate the answers derived by employing the correction rules with chart and the actual calculated answers from the Range and Deflection Computers.

From the preceding discussion and comparison of values it will be seen that firing data taken from the chart is not absolutely accurate but if the foregoing rules are carefully applied the maximum errors in any case will not exceed the following:

Fuse Range.....two tenths (0.2) of 1 Fuse Range Number.
Vertical Deflection...−5 Mils.
Lateral Deflection.... 5 Mils.

It is further believed that firing data for targets whose engine speed ranges from 95 to 125 miles per hour can be taken from the chart with sufficient accuracy to render its use practicable against day bombers whose normal speeds at present are, and for some time will continue to be, within these limiting values.

A chart, similar to that shown in Figure 1, can be built for the 75-mm Gun, Truck Mount, by filling in the Lateral and Vertical Deflections on the chart shown in Figure 2. The rules above laid down for the 3-inch mount apply equally well to the 75-mm. The chart, in the size issued by the JOURNAL, is suitable for both drill purposes and actual firing and it is suggested that the chart be pasted upon a board or table of appropriate size and covered with shellac.

The authors desire to acknowledge the timely suggestions and assistance of Master Sergeant Carl M. Taute, C. A. C., in the preparation of the drawings that appear in this article and those contained in "The Cotangent Method of Fire Control," published in the November, 1922, issue of the COAST ARTILLERY JOURNAL.

EMERGENCY FIRE CONTROL SYSTEM
3"AA GUN MODEL 1918
TRAILER MOUNT

SPEED OF PLANE 110 MILES PER HOUR
M.V. 2409-AA.SHELL MARK I
FUSE MARK II

POSITION OF PLANE

PASSING +90°

PASSING -90°

COMING +75° +60° +45° +30° +15° 0° -15° -30° -45° -60° -75°

GOING +75° +60° +45° +30° +15° 0° -15° -30° -45° -60° -75°

H = Altitude.
R = Fuse Range
V = Vertical Deflection.
L = Lateral Deflection
Fig. 1-5 = Altitude in 1000 yds.

POSITION OF BATTERY COMDR & GUNS

FIGURE 1

SPEED OF PLANE 110 MILES PER HOUR.
M.V. 1825-A.A. SHELL MARK III.
FUSE MARK III

EMERGENCY FIRE CONTROL SYSTEM
75 mm. GUN MODEL 1916
TRUCK MOUNT

POSITION OF PLANE

POSITION OF BATTERY COMDR & GUNS

5008

FIGURE 2.

Angle of Approach in Degrees	Altitude in Yards	Angular Height in Degrees	Engine Speed in Miles per Hour	Results: Using Chart and Correction Rule			Results: Calculated with Range and Deflection Computers		
				F. R.	V. D.	L. D.	F. R.	V. D.	L. D.
Going 0	2000	30	100	14.8	275	300	14.6	280	300
" 0	4000	75	120	12.6	255	300	12.5	250	300
" +15	3000	30	100	22.0	275	315	22.0	275	318
" +15	4000	75	120	12.6	255	330	12.5	252	326
" −15	2000	30	120	15.0	280	280	15.0	278	283
" −15	5000	75	100	15.2	250	275	15.2	255	274
" +30	3000	30	120	22.0	275	345	22.0	274	345
" −30	2000	75	100	6.2	275	275	6.0	276	272
" +45	3000	30	100	20.6	280	355	20.6	283	351
" −45	4000	75	120	12.2	270	225	12.0	266	225
" +60	3000	30	100	19.6	290	365	19.6	290	362
" −60	4000	75	120	12.0	280	210	12.0	278	208
" +75	3000	75	120	8.6	295	390	8.8	294	290
" −75	2000	30	100	12.4	295	250	12.4	297	247
Passing +90	3000	30	120	23.2	300	390	23.2	300	393
" −90	4000	75	120	11.4	300	180	11.4	300	180
Coming +75	5000	75	100	13.8	310	420	13.8	308	417
" −75	4000	30	120	21.4	305	200	21.4	307	205

Doctrine of Anti-Aircraft Defense in France

Report from the Military Attache in France, furnished through the courtesy of the Military Intelligence Division, War Department General Staff

THE doctrine of anti-aircraft defense in France has been well described in a series of lectures by Major Fontaine who is now head of the Anti-Aircraft Bureau of the Direction of Artillery. The following information is taken from these lectures which may be considered as an expression of the official opinion of the principles of anti-aircraft defense as now held in the French Army.

The rôle of the anti-aircraft defense service is considered to be as follows:

1. At all times both day and night:—
   (a) To keep headquarters and the Air Service informed concerning all activities of the hostile air service.
   (b) In case of probable aerial attack to warn all persons concerned in sufficient time.
   (c) To provide both military and civilian authorities with information concernng the construction of bomb-proofs against aerial attack.
2. Day time:—
   (a) Cooperate with the Air Service to prevent, by direct attack hostile airplanes from crossing the line, and, if they succeed in crossing, to hinder them in accomplishing their mission.
   (b) To hinder aerial observation by means of camouflage.
3. Night time:—

To insure protection against aerial attacks of important points in the zone of the army and in the interior such as headquarters, parks, depots, stations, etc.

   (a) By attacking directly with artillery the hostile airplanes at certain points in their course and close to the important places to be defended.
   (b) By creating by means of searchlights or any other means, zones of illuminated space within which pursuit planes can operate.
   (c) By putting permanent obstacles in the probable routes of airplanes.
   (d) By seeking to lead hostile airplanes astray by the camouflage of the most probably used reference points.
   (e) By making targets invisible or modifying their aspect by camouflage.

The resources available in the service of anti-aircraft defense are as follows:

1. Telephonic and wireless communications of a very complex nature, especially installed with a view to anti-aircraft defense or in common with the anti-aircraft defense and the Air Service.
2. Anti-aircraft artillery including batteries of 75-mm automobile guns, 75-mm guns on towed mount, 75-mm and 105-mm guns on platform mounts.
3. Electric searchlights of various calibers grouped in companies of 4 or 6 sections of 4 searchlights each.
4. Machine guns grouped in companies of 4 sections of 8 guns each.
5. Listening apparatus.
6. Balloons for anti-aircraft defense in units, each of which includes 10 balloons of the simple or double type.
7. Camouflage in all forms.

THE ANTI-AIRCRAFT SERVICE AS A SOURCE OF INFORMATION

The anti-aircraft defense which is always on guard forms an excellent service of information concerning all hostile aerial activities. The information obtained can be classified in three categories:

1. Information Utilized for the Defense of the Territory

The first duty of the anti-aircraft defense is to prevent all possibility of surprise from the air. Every airplane which passes the border must be immediately noted, cataloged and followed the entire time it is over friendly territory, and its approach should be signalled in time to those concerned. The detecting system is made up of one or more parallel lines of observation posts situated at a distance from each other not exceeding 15 kilometers so that it is impossible for an airplane to fly over the lines without being seen or heard. These observation posts are united by groups to "Information Centers of Anti-Aircraft Defense" and these in turn united to the "Centers of Anti-Aircraft Defense." The transmission should not be used for any other purpose than for anti-aircraft defense. The defense of Paris at the end of the war included 80 special observation posts distributed over concentric circles, the largest of which had a radius of about 100 kilometers, to which must be added the firing positions which form at the same time observation posts.

2. Information Furnished the Air Service

The information may be of an immediate nature or may be furnished in a daily message. The immediate information furnished the headquarters of the Air Service or directly to the groups of combat airplanes concerns sudden activity of the enemy air service or the activity of the

enemy air service during a portion of the day. Such information is in the form of number of airplanes seen in the various sectors of the army, types of airplanes, and their probable missions. The daily messages are furnished in the morning concerning the aerial activity of the preceding night, and in the evening concerning the aerial activity during the day.

3. Information Furnished Headquarters

The intentions of the enemy can be deduced from his aerial activity and for this reason each commanding general of an army receives daily reports concerning enemy aerial activity.

ANTI-AIRCRAFT ARTILLERY

At the present time there are three types of 75-mm guns used in the anti-aircraft artillery: the 75-mm automobile mount; the 75-mm gun on towed mount; and the 75-mm gun on platform mount.

The 75-mm automobile mount is mounted on an automobile chassis which is supported on the ground by means of jacks when fire is opened. It is very mobile but has difficulty in leaving roads. On good ground it is ready to open fire in a few minutes.

The 75-mm mount on towed mount is a small 75-mm turret towed by a tractor. It is less mobile than the preceding gun but it may be employed on all kinds of terrain. It takes about half an hour to put it in battery.

The 75-mm automobile mount has a dead angle in azimuth of 110 degrees and in elevation of 40 degrees which corresponds to an altitude of 5000 meters on a circle of 1600 meters radius. This is a great disadvantage in the case of this matériel.

The 75-mm gun on towed mount has no dead angle in azimuth but has the same dead angle in elevation as in the preceding case.

The 75-mm gun on platform mount for the defense of the interior has no dead angle in azimuth but in elevation has a dead angle of 30 degrees, which corresponds to 5000 meters altitude on a circle of 1300 meters radius.

The projectiles fired by these guns are as follows:

1. High explosive shell, model 1900, containing about 750 grams of explosive, which is only effective at about 15 meters from the point of burst. It is the best projectile available for anti-aircraft defense but unfortunately it cannot be used at altitudes greater than 4000 meters.

2. The shrapnel with a 30/35 fuse which can only be used at less than 5000 meters altitude since above this height its remaining velocity is such that the balls are no longer effective.

3. High explosive shell, model 1917, which has better ballistic properties than the 1900 shells but which has 100 grams less explosive. It retains its effectiveness up to an altitude of 5500 meters.

4. The tracer shell which is especially designed for fire against balloons and dirigibles.

The 105-mm gun on platform mount is simply the 105-mm field gun adapted to this purpose. There are about 100 available for service. In this case, only shrapnel is used, which has sufficient effectiveness up to altitudes of 6500 meters.

Inasmuch as certain types of airplanes fly normally at 6000 meters it is evident that the 75-mm gun is ineffective against such planes. The future gun for anti-aircraft artillery to be effective must fire at velocities approaching 1000 ms. The 105-mm guns already furnished by Schneider and Company to the French War Department have a muzzle velocity of 700 ms which gives them a horizontal range of 15,000 meters and a maximum ordinate of 9800 meters. They fire a projectile containing 2.200 kilograms of explosive.

LISTENING APPARATUS

A trained observer is able to estimate the azimuth of an approaching airplane without apparatus with a mean error of 20 to 30 mils, and the site with a mean error of 60 to 80 mils.

The forms of apparatus used to determine the position of an airplane by sound are the Baillaud apparatus, which is heavy and cumbersome and can only be used in fixed installations, and the Perrin apparatus, which is based on a different principle from the Baillaud instrument. The Perrin apparatus includes a site measuring instrument which is pointed in azimuth by the observer whose ear is uncovered, and which is used only to determine the angle of site. The telesitemeter gives the azimuth of the source of sound by combination of two angles which are neither the azimuth of the target nor its site. This latter instrument has a range of about 7 kilometers and has about the same accuracy as the Baillaud apparatus which has a range of 8 kilometers, and gives measurements with an approximation of 10 to 20 mils.

SEARCHLIGHTS

The function of the searchlight in the defense against aircraft is to illuminate hostile airplanes during a sufficiently long period to permit direct fire by the artillery or night pursuit by the aviation. Searchlights used by the French anti-aircraft defense are 90, 120 and 150 cm in diameter, and their approximate effective ranges are given in the table on Page 58.

The searchlights are mounted on wheeled carriages, hauled by an automobile which contains the generator.

Searchlights are used by groups of at least 8 lights placed at a distance of about 3 kilometers from each other so that an airplane in the beam of one of them and kept in the beam up to the limit of its range can be taken up by the beam of a neighboring light and in this way

EFFECTIVE RANGES OF SEARCHLIGHTS

	Atmospheric Condition					
	Light mist		*Average atmosphere*		*Very clear weather*	
	On dark colored airplane	*On light colored airplane*	*On dark colored airplane*	*On light colored airplane*	*On dark colored airplane*	*On light colored airplane*
90 cm	1900	2000	3000	3500	3600	4200
120 cm	2300	2400	4000	4500	4900	5700
150 cm	2500	2600	4500	5000	5600	6500

pass from searchlight to searchlight. A searchlight company has 24 searchlights.

Searchlights for use against airplanes must on no account be regularly located about the point to be defended, as in this case they would serve as beacons to the enemy. They must also be frequently moved from one place to another.

For night pursuit work searchlights are united in groups of at least one company. They cover an area of ground above which any hostile airplane will be illuminated during a sufficiently long period to permit our airplanes to attain them and drive them down. Night pursuit requires a very extensive zone of action in which there must be no other means of defense against airplanes. It can only be successful where there is a close understanding between the pursuit aviation and the searchlight service. The night pursuit zones are selected preferably far from important places to be defended but always in such a way as to bar the routes that bombardment planes must take to reach their target. Their position is frequently changed. Night pursuit in a region can be assured by a grouping including a pursuit aviation formation and one or more companies of searchlights. This grouping is very mobile. If given orders in the morning, it can organize at a distance of 50 kilometers from its position at that time, a night pursuit zone where it can operate the same night.

Use of Machine Guns and Automatic Guns of Small Caliber

In using machine guns against aircraft flying low, the range is measured with a small extremely simple apparatus whose principle is based on that of the Stadia.

The Cazaux Labat corrector is the regulation corrector in use for these machine guns.

Inasmuch as in this firing, accuracy is somewhat sacrificed to obtain rapidity and facility of firing, effectiveness is sought for especially by density of fire. An isolated machine gun is never used. Anti-aircraft

machine guns should always be used in groups of at least 8 machine guns echeloned with reference to each other both in azimuth and in elevation, and fire is carried out by burst of from 15 to 20 shots from each gun. Six Lewis machine guns in the case of a particular mount were united on the same chassis. When the guns were aimed, the gun pointer opened fire at the same time with the 6 machine guns, each of which fired a magazine of 100 cartridges.

There is no doubt but that in the future more powerful and heavier machine guns must be used by front line troops to assure their defense against aircraft, as well as automatic guns of small caliber.

The automatic gun will have a very high rate of fire and a muzzle velocity of about 1000 ms in order to permit direct fire with a simplified sight of the corrector type. The projectile used will be a small explosive shell supplied with a fuse sufficiently sensitive to cause a burst on contact with any part of the airplane. Percussion fire is therefore anticipated for this type of weapon.

CAMOUFLAGE

During the war camouflage, which at first had been exclusively directed as a preventive against terrestrial observation, became towards the end a means of protection against aerial observation almost exclusively and for that reason the camouflage service was attached to the anti-aircraft defense in 1918.

LEARNING WITHOUT THOUGHT IS LABOR LOST

THOUGHT WITHOUT LEARNING IS PERILOUS.

—*Confucius.*

Tables of Organization, French Anti-Aircraft Artillery

Report from the Military Attache in France, furnished through the courtesy of the Military Intelligence Division, War Department, General Staff.

Anti-aircraft artillery in France includes:

4 regiments stationed in France

1 regiment stationed in Army of Occupation on Rhine

1 searchlight detachment in Morocco.

The four regiments in France include:

A. 1 regimental staff

B. 1 headquarters platoon including a regimental automobile repair section and a regimental searchlight repair section.

C. 1 battalion of 4 mobile batteries

D. 1 mixed battalion including

  (a) 2 mobile batteries

  (b) 3 platform gun batteries

E. 1 mixed battalion including

  (a) 2 searchlight companies

  (b) 1 mixed company of balloonists, machine gunners and camouflage experts.

The 3rd regiment has a supplementary mixed battalion.

The anti-aircraft regiment stationed in Germany has A and B as above, 4 battalions of 2 mobile batteries each and 1 searchlight company.

STAFF OF AN ANTI-AIRCRAFT ARTILLERY REGIMENT

Colonel	1
Lieutenant-Colonel	1
Majors	3
Medical Officer	1
Captain in charge of instruction	1
Captains or Lieutenants for adjutants	2
Captain in charge of Park	1
Captain in charge of mobilization and enlisted personnel	1
Captain paymaster	1
Captain in charge of matériel	1
Total	13

ANTI-AIRCRAFT BATTERY

Commissioned	*Battery of*		*Searchlight company*
	75-mm mobile guns	*75-mm platform guns*	
Captain	1	1	1
Lieutenants	2	1	1
Total	3	2	2
Enlisted personnel			
Warrant officers	2	2	2
First Sergeant	1	1	1
Q. M. Sergeant	1	1	1
Sgt. Mechanician	½	0	½
Sgt. Artificer	1	1	0
Sgt. Artillery Mechanic	1	1	0
Sgt. Electrician	0	0	1
Sergeants	4	4	5
Corporal gun pointer	1	1	0
Corporal telephonist	1	1	0
Corporal wireless operator	½	½	0
Corporal mechanician	½	0	½
Corporals	5	5	7
Automobile mechanics	4	4	2
Machinists	1	1	4
Artillery mechanics	1	1	0
Auto repair specialist	1	0	0
Electricians	0	0	2
Musicians	2	2	2
Privates, 1/5th of whom are first class gunners			
Gunners	43½	54½	38
Chauffeurs	24	0	14
Total in organization	95	80	80

(*Editor's Note:* The reader may share with the editor a certain wonder as to how ½ a man is assigned in certain places.)

MIXED COMPANY

Headquarters Section

	Officers	*N.C.O's*	*Corporals*	*Privates*
Captain	1	–	–	–
Warrant Officer	–	1	–	–
1st Sergeant	–	1	–	–
Q. M. Sergeant	–	1	–	–

	Officers	*N.C.O's*	*Corporals*	*Privates*
Corporal	–	–	1	–
Privates	–	–	–	10
Total	1	3	1	10
BALLOON SECTION				
Lieutenant	1	–	–	–
Warrant Officer	–	1	–	–
Sgt. Mechanician for automobiles	–	1	–	–
Sergeants	–	3	–	–
Corporal auto specialist	–	–	1	–
Corporals	–	–	4	–
Privates (Winch details)	–	–	–	24
Privates (Chauffeurs)	–	–	–	8
Privates (cable detail)	–	–	–	10
Privates (various)	–	–	–	6
Total	1	5	5	48
MACHINE GUN SECTION				
Lieutenant	1	–	–	–
Sergeants	–	2	–	–
Corporals	–	–	3	–
Privates	–	–	–	30
Total	1	2	3	30
CAMOUFLAGE SECTION				
Sergeants	–	1	–	–
Corporals	–	–	2	–
Privates	–	–	–	10
Total	–	1	2	10
Total in unit	3	11	11	98
	3		120	

EDITORIAL

The Work That Lies Ahead

THE reader of Colonel Barnes's thoughtful article in the December JOURNAL on "The Mission of the Coast Artillery Corps," will be reinforced by the War Department's recent pamphlet entitled "The Progress of the War Department in Compliance with The National Defense Act of 1920" in the conclusion that for the time being the Coast Artillery in the continental United States is reduced to the basis of a care-taking and training nucleus. On page 6 of the Pamphlet just mentioned occur the following statements:

"Incident to the reduction of the Army to its present strength, it has been necessary to reduce the numbers allotted to the Coast Artillery Corps so that tactical or strategic considerations relative to their assignment to the different harbors along our coast have had to be disregarded. These assignments have necessarily been made with the purpose of facilitating the necessary training of the troops and permitting of their supply in the most economical manner."

"There have been allotted for duty with the harbor defenses in the continental United States 3,436 coast artillerymen. This number includes the garrisons of the 10 harbor defenses in commission, as well as the caretaking detachments required at the 15 defenses out of commission. This strength is less than 10 per cent of that required to operate all of these installations in time of war."

A careful reflection concerning the situation confronting us for the immediate future is highly in order and should lead us to several interesting and important conclusions. In the first place it may be seen that at least for the next few years, the only opportunity for young officers to gain through experience and personal observation a well rounded conception of the functioning of a complete coast defense system will be afforded by foreign service either in the Philippines, Hawaii or Panama. For only at these foreign stations are the garrisons being maintained at sufficient strength to permit even fire commands to function, much less tactical coast defense commands.

This observation leads us to another conclusion. It has been well recognized by many thoughtful Coast Artillerymen since the War that the tactical conceptions for the employment of coast artillery fire which

were well standardized before the War and which prior to the experience of the War were considered to be adequate are now no longer so to be considered. Many of us have brought over from our war experience the conviction that success in coast defense operations demands an effective concentration of fire to an extent and in terms which a few years ago would have been thought unnecessary and even impossible. Before the War most of us conceived coast artillery fire tactics in terms of battery units. We are now convinced that success in War will be predicated upon fire units of not less than fire commands, and fire commands transcending by at least 100 per cent in number of guns those which were conceived as normal before the War. If this growing belief is well founded, it then follows that we are confronted with the necessity of developing the necessary technique for controlling the fire against naval targets of such heavy concentrations, and confirming the technique thus developed by practical experience and constant practice. So that in this important element of the work ahead of us, an unparalleled opportunity, indeed the exclusive opportunity, is thrown into the hands of those on foreign service. This opportunity may perhaps logically be divided into two rather distinct phases. First of all it is quite necessary that everyone, officers and men, in these garrisons, be instructed in a sound knowledge of the methods which are now standard in the Coast Artillery. Then upon the sure foundation of familiarity with what has already been developed and proven by experience, may be built the necessary progress for future efficiency.

If the reader is inclined to agree so far, it is then proper to consider what the necessary elements of this desired progress may be considered to be. It seems reasonable to discuss them under the headings of

1. Communications
2. Fire Control
3. Observation of Fire
4. Intelligence.

Communications. While concentration of fire is the object to be attained, yet dispersion of the guns and other elements of command is tactically demanded even if it did not exist in fact. Consequently the first requirement for effective concentration of fire is the perfection of our communications so that even with an increase in the number of elements in a fire unit, certainty of operation may be guaranteed through the perfection and if necessary, duplication of the technical means of communication, and through the simplification of the requirements for the transmission of commands and of data. From a fire control standpoint some of the considerations involved have already been discussed by Major Bender of the Signal Corps in the July, 1922, issue of the JOURNAL, but we must look to further demands for the simplification of communications required in our new conceptions of the functions of command, and of observation and intelligence. Some of these problems

will immediately become apparent when we attempt to elaborate these last mentioned functions, and it is beyond the scope of the present comment to indicate the path of progress other than to sound a warning against a too ready and unthinking reliance upon the employment of radio. To say nothing of the difficulties of interference, the very volume of communications traffic would preclude a resort to radio under battle conditions, except as a distinctly emergency measure, and it is believed that the use of radio should be developed largely from this standpoint.

Fire Control. If the fire of not less than eight guns of related caliber and range is to be susceptible of elastic and certain concentration upon a given objective, it is necessary that the present methods of target location and relocation be amplified by the practical development of devices and methods which at the present time are only in an experimental stage. The primary importance of "hits per gun per minute" should constantly be kept in mind. With this principle constantly to the fore it will be admitted that the fire control methods should be such that the only limitation on the rate of fire will be the time necessary to load and lay the gun. Furthermore the method of fire for war should be based upon the utilization of the maximum fire power from the start, even if some ammunition seems to be wasted in the process. This appears to be one of the unavoidable evils of our peacetime target practice, for here the allowance of ammunition is so limited that we are very prone to develop methods which ignore the truth that in time of war immediate and positive effect is the principal consideration, to be attained even at the expense of some apparently wasted ammunition. As a corollary of our natural peace time tendencies, we are quite inclined to favor methods of fire adjustment which presuppose the individual spotting of splashes, and the exact determination of the value of deviations. This matter will again be referred to under the subject of *Observation of Fire*, but here it is sufficient to observe that we are faced by the necessity of developing not an ideal method of placing the center of impact exactly on the target, but of utilizing the information to be obtained by the simultaneous arrival of perhaps eight splashes in such fashion that the center of impact may be brought and kept sufficiently near to the hostile ship so that in a continuous series of rapid salvos, a sufficient number of projectiles will attain effect. Another problem which concerns the fire control element in our discussion is that which has frequently been suggested, notably by Major Sanderford Jarman in his article entitled "Land Artillery to the Fore," in the October, 1922, issue of the JOURNAL, as to the propriety if not necessity of "zoning" our guns so as to control the angle of fall to give us the greatest chances of deadly effect. Still another element of our fire control problem is the practicable development of airplane cooperation in fire control, a suggestive start toward which was made in the firings at Fort Story, using the method suggested by Major Norton, and which is so well described

in Captain Ricker's Report in this issue of the JOURNAL. The importance and difficulty of this problem can hardly be over-stated. It should be remembered that while a remarkable degree of success was obtained by Captain Ricker in this initial experiment, yet he was using but one gun, and rate of fire was not a controlling element in his problem.

Observation of Fire. It is perhaps not too much to say that in all the discussion which has so far been carried on with regard to observation of fire, we have not yet fully and frankly faced the tactical demands of this phase of our problem. Even in handling the one element of terrestrial observation, we have largely ignored two controlling considerations, the first of which is that an effective observation service can not be improvised nor superimposed as an additional duty upon the personnel charged with target location, and the second is that bilateral observation will be practically out of the question due to the demonstrable impossibility of getting two observers separated by a practicable base line on the same splash, when a large number of splashes are appearing at the same instant. The statement has frequently been made that whenever the sense of a splash can be determined, its actual deviation from the target can also be determined. Under battle conditions, this contention is bound to be both false and fatal. Consequently, as one necessary principle in the observation element of our problem, it is confidently asserted that we must develop as we have not yet developed a practicable means of observing and reporting either the mean point of impact of a salvo, or (what will lead to the same result) the definite sensing of all the shots of a salvo. The suggestion has been made by Major Fred Green in his article on "Our Minor Armament" in the June, 1922, issue of the JOURNAL that we adopt a leaf from the Navy's book in determining positively the proportion of *shorts* in a salvo, when firing minor caliber guns. It should be the subject of definite experimental determination whether this principle is not equally valid for the control of fire for major caliber guns. But after we have gone the limit of perfecting methods of observation of fire by terrestrial observation even under the most difficult conditions of darkness, fog, or smoke screen, there yet remains the whole question of a definite standardized system of cooperation between the Air Service and the Coast Artillery in aerial observation to be attained. Here and there in the last few years there have been some notable examples of successful cooperation of this kind. But it is not too much to say that the problem will not have been solved until each officer in the Air Service and each officer in the Coast Artillery shall have shared in personal participation in this cooperation, and until all the processes involved shall have been as definitely standardized as is now the Coast Artillery's method of tracking targets by the use of a horizontal base. Finally, the problem of observation of fire will not have been solved until the question of a separate and definite organization for the purpose shall have been de-

veloped by actual experience, the necessary system of training and control of the observation service established, and tables of organization evolved.

Intelligence. Alike with the definite facing of the problem of an observation service, the subject of tactical intelligence for coast defense action has been given only the most meagre consideration. The first definite suggestions in this direction were represented by the effort of Captain J. D. MacMullen in his work in the Coast Defenses of Chesapeake Bay, the preliminary results of which were embodied in his article "The Organization of a Harbor Defense for War" in the May, 1922 issue of the JOURNAL. Whether or not the particular methods suggested by Captain MacMullen are in the direction of ultimate development can not be foretold, but at least he opened up the problem and suggested the importance of its solution. Perhaps the development of battle efficiency in so far as this element of our problem is concerned is the most difficult part of our work, due to the seeming impossibility of visualizing through the employment of a few paltry harbor boats, the rapidly changing and easily bewildering panorama which would confront a coast defense commander if attacked in force by an ably led hostile fleet, complete in all its elements. However, it is proper to observe that here as in many other features of our work success can be spelled only by the employment of an active, trained imagination, a quality which is notably not a part of the recognizable mental equipment of most of us. Nevertheless, it should now be possible for most of us to realize that the movements and action of a complete modern fleet will not be a stereotyped, cut and dried affair, the course of which may be forestalled by some preconceived sequence of orders. We have come to realize that a coast defense commander must be mentally equipped, like any other military commander, with the ability to estimate quickly, decide immediately, and formulate commands without hesitation, if the aggregation of fire units under him is not to degenerate in the stress of action to inchoate and uncontrolled and consequently ineffective efforts on the part of subordinates, who can not be alive to the critical phases of a naval attack as the coast defense commander should and can be. Manifestly, if he is to have available in sufficient time all the data of tactical intelligence which are necessary for him in order to arrive at effective estimates and decisions, he must have at his disposal the personnel and mechanical accessories necessary to collate that intelligence for him in usable form. If his intelligence personnel is to serve him effectively, it must be devoid of other responsibility and must be definitely organized and trained for the task. So here is an almost untilled field in the work ahead of us.

All that has so far been said has emphasized the obligation and the opportunity of those who may have the privilege of foreign service within the next few years. It is reiterated that in view of the fact that

only in these foreign stations will the combination of men and matériel be available in sufficient numbers, that this emphasis on the privilege of foreign service is not over-stated. However, what of the Coast Artillery in the United States? Have we no definite work ahead? Or if we have, is it merely grinding unproductive routine? By no means.

Aside from our traditional and routine obligations there is one responsibility and one opportunity which confronts the Corps as a whole. This opportunity consists in the wider development of Anti-aircraft Defense. We are on our way—well on our way in this field—but only a start has been made. Two objectives may properly be held before us during this year. The first is that every Coast Artillery officer may become personally familiar with the technique of Anti-aircraft Defense in all its elements so far developed. This is a general challenge. Another which would affect only the few who have the background of experience to start them on the way is the development and subsequent perfection of a *single station system* of Anti-aircraft fire control.

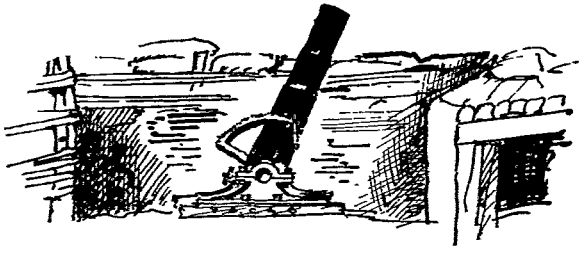
Now as for routine, wherever we may be and on whatever duty, whether it be in charge of a caretaking detachment, commanding a coast artillery unit, on a coast defense staff, running a Post Exchange, instructing the National Guard or Reserves, or in an R. O. T. C. unit, there are two distinct opportunities which lie immediately ahead for all of us. The first is to utilize to the fullest extent whatever faculty we may possess of independent thought and so use it that we may devise a more efficient, more economical and more time-saving method of accomplishing the task at hand. For however unrelated to War our present duties may be, if we but stop to think there is almost no kind of duty that any of us may now be performing but what will require its counterpart in a wartime army. Then the same work, whether it be handling a battery, running a Post Exchange or training recruits or what not, will still have to be done, and then done on a vaster scale and in a far more driving fashion than is now required in peace. While it is true with the mobilization of the Nation's forces for war in the Coast Artillery, whether Regular, Reserve or National Guard, each of us will fill the duties of a higher grade than we now hold, yet it is altogether likely that a part of those duties will consist in the training, supervision and advising of junior officers who will then be called upon to perform the duties which now are ours. In the development of our great American Army in the World War, it was the leaven of confirmed habit and attained method in the hands of the few Regulars and National Guardsmen, which spread through the whole vast organism. Nevertheless, we can feel sure through our own observation and recollection that there were many of the pre-war Regulars and National Guardsmen who had not sufficiently digested and coordinated their own previous experience in minor and perhaps routine duties so that they were

able the most effectively to hand on military method to their war-time subordinates. Let no one of us ever be caught in such fashion again. Now is the time not only to perform work satisfactorily, but to conceive how best to train and supervise a junior in some later day to handle that same duty. If we believed that there never would be another war, or that we would never be called upon to progress in the military service and exercise higher command and greater responsibility, the game would not be worth the candle. Because we do believe that we are preparing for greater responsibility, it is worth our while to confirm in our own present experience a sound knowledge of effective method in the task in which we are now employed.

The second definite opportunity which lies immediately ahead of each of us in the Coast Artillery in the United States, is a corollary to the opportunity of developing sound method. It is the opportunity of striving to fit each of our subordinates for a war responsibility in excess of that which he now holds. There are but few of our soldiers so indifferent and so unintelligent but what they may be susceptible to definite improvement with a view to increasing their fitness for higher responsibility in war. This effort on our part is to be considered well worth while even if the object of that effort is only a soldier whom we know is soon to be discharged and leave the service, perhaps forever. If we but stop to think we will realize that if that much dreaded "next war" comes it will involve to an even greater extent than the last the man power of the United States. Under these conditions almost every man who has had a modicum of military training will presumptively possess an enhanced value to his country. Many of us had occasion to serve during the War with non-commissioned officers, many of whom had never been more than privates before the War, who had never previously visualized themselves in a position of responsibility, and who consequently did not measure up to the need of the hour even though they had to be used, simply because they were better equipped than the wholly untrained men. How much better it would have been if even the most seemingly worthless of these pre-war soldiers had been forced at least to visualize the situation in which he would find himself if he were called upon to command a squad all of whom were recruits and not old-timers like himself. However, this is but one phase of this particular opportunity. Now sooner or later all of us will be in the position of having other officers as subordinates. If we but stop to think, how heavy a responsibility and how great an opportunity rests upon us of insuring that by our tacit example and specific suggestion we guide these juniors to a sure knowledge of right method, of discriminating observation, of daring initiative and of studious habits. Many of us may know, as some of us surely do, that there have been commanding officers in the past who all unwittingly have raised tremendous havoc with the future of their young officers by giving these

youngsters the impression that there is something funny about serious thought. Spontaneity and initiative lie more innate in the youngster than in the old whose enthusiasms have perhaps been punctured, whose experiments have failed and whose efforts have been frustrated. The very recognition of this natural tendency on the part of the young to spontaneous activity should prompt us to the utmost care that we avoid thwarting and dwarfing it and that we help instead to guide it into useful and productive channels.

So take it as we will, we are justified in concluding that notwithstanding the havoc and chaos which have so far confronted the Coast Artillery and the rest of the Army since the War, there is work ahead, work that is worth while and a game to play that is worth playing. If we can not so believe we had much better have joined some of our friends and comrades who have left the service within the last few months. But we can and do believe it as is evidenced by the fact that we are here. With the advent of a new year we may hope that our good purposes may not be further thwarted by unfortunate legislation, and that we have reached the threshold of a year and an era in which we may be able to put aside the unsatisfying query "where do we go from here?" and may have the ground for a spirited acceptance of the courageous slogan—"Let's Go!"



Employment of Heavy Artillery—Problem No. 6—A Solution

1st Requirement:

Maj A summons his battery commanders and staff and gives following verbal orders:

"An attempt to pierce the front of the 3d Corps is expected within the next 24 hours. The Corps will hold its ground at all costs.

This Bn will support the 3d Corps front by firing counter-battery and destruction fires.

Batteries will fire on targets indicated in schedule herewith upon receipt of orders putting schedule into effect from these headquarters. The rate of fire will be the maximum possible until each target has received two bursts of fire. Thereafter an average rate of 1 shot per piece every 5 minutes will be maintained.

Batteries will be prepared for local defense.

In event of hostile infantry reaching battery positions all matériel will be destroyed.

The Battalion Supply Officer will obtain the wire, stakes, hand grenades, and thermite grenades necessary to carry out the local defense scheme already agreed upon and will deliver it to battery positions by 9:00 PM today.

Messages to Battalion Headquarters here.

Are there any questions?"

FIRING SCHEDULE NO. 1
1ST BN 901ST ART

Target	*Battery*	*Total Shots Per Target*	*Remarks*
8	A (1 plat)	96	Superquick fuses will be used against all
9	A (1 plat)	96	targets for the first four rounds.
5	B (1 plat)	96	Thereafter, fuses will be short delay with
7	B (1 plat)	96	one superquick in each four shots.

2nd Requirement:

1. A thermite grenade dropped in the muzzle of each mortar will fuse the breech block to the bore, and is the most effective means of destroying the mount. A sledge properly used can effectively destroy the recoil cylinder and recuperators. Thermite or incendiary grenades might be used for destroying ammunition and matériel. All matériel must be rendered useless to the enemy.

2. If no thermite grenades are on hand, any means which will destroy the

matériel, rendering it useless to the enemy, in the time available may be employed. The following is one method:

Smash recuperator plunger and pull rods with a sledge. Load and fire at 0° with breech block partially closed, and safety device removed, use being made of a long lanyard and convenient dugout. If time were available, the recoil cylinders could be drained before firing. Set off powder in ammunition cars with time fuses, or with black powder taken from one or two cars. If retreat is cut off, remove rail, couple switch engine to remaining cars, and run train over the embankment.

Employment of Heavy Artillery—Problem No. 7

References: Maps, Gettysburg 3-inch, Bonneauville and Gettysburg Sheets, and 1-inch reduced from 12-inch War Game Map; T. of O. 742 W published in July JOURNAL.

General Situation: In continuation of Problems 1, 3, 5.

The hostile attack of 29 March resulted in the loss of a portion of the outpost zone of the 3d Corps. The attack was stopped at the main line of resistance but our counter attack failed to recover the ground lost.

The line of contact on the front of the III Corps now runs along 351.6 - 743.8, 354.0 - 743.7, 356.0 - 747.1 - Hill 571 - CR 588 - Round Top SH.

Special Situation (Blue): For some days following the attack of 29 March, the 1st Bn 701st Art remained in position near MEYER FARMHOUSE and very little firing was required of the battalion. A brigade field order was received 12 April directing the battalion to take part in an attack to be made by the III Corps on D day at H hour; the object of this attack was the retaking of the original WHITE RUN lines. (Corps Hq. at MT. PLEASANT SH). The Corps administrative order received same day contained the following pertinent information:

"Ammunition Distributing Point for Corps Artillery: Army Depot at LEFEVRE—(366.0-740.6).

Evacuation of sick and wounded Corps troops to nearest Divisional Hospital Station or Collecting Station.

Convoys and trains of more than 2 vehicles will not operate in the Corps Area during daylight."

At 9.00 AM 16 April a message was received from BHQ announcing D day as 17 April and H hour as 5.00 AM.

1st Requirement:

Capt. B, the C.O. of the Bn Comb Tn was directed on 16 April at 9.00 AM to get 800 rounds of ammunition to the battery positions by 4 AM 17 April.

Give in detail his actions to obtain this ammunition stating the number of trucks required to move it, the strength of the detail required to load it, the time he would have his train at the dump, the time it would take him to load and the time it would be delivered to the batteries. He is allowed to use the following route: From position of rear echelon via CR 595 - RJ 593 - PLEASANT HILL SH - RJ 623 - LEFEVRE, returning via same route to CR 595, thence via CR 621 to battery positions. Capacity of 3 ton cargo truck is 20 rounds of 8-in. howitzer projectiles, or 234 charges for Mark VI, in 78 containers on end.

2nd Requirement:

During the engagement of 17 April the battalion suffered 30 casualties divided as follows: Dead 6 - Seriously wounded 9 - Slightly wounded 15. Give in detail your disposition of each class including disposition of individual clothing and equipment and records. State your action taken to get replacements of personnel. The nearest Collecting Station is at TWO TAVERNS, and the nearest Divisional Hospital Station is at LITTLESTOWN.

THE BULLETIN BOARD

EXAMINATION FOR GUNNERS, COAST ARTILLERY CORPS

Prepared under the direction of The Chief of Coast Artillery

Editor's Note.—This paper is one of a considerable series of Training Regulations for Coast Artillery, prepared under the direction of the Chief of Coast Artillery. This paper has been officially approved and is under process of publication by the War Department. Due to shortage of funds most of these Training Regulations cannot be put out officially during the current fiscal year. On account of the importance of the Regulations "Examination for Gunners, Coast Artillery Corps" they are being unofficially printed herewith at the suggestion of the Office of the Chief of Coast Artillery. When officially published they will bear the designation Training Regulations No. 435-310.

SECTION I.
OBJECT OF EXAMINATION.

1. **Object of examination.**—The object of this examination is to determine specially qualified enlisted men and to furnish a basis for their classification as gunners.

SECTION II.
CLASSIFICATION OF GUNNERS.

2. **Classification of gunners.**—Gunners will be divided into three classes; viz., expert, first class, and second class, classification depending upon the scope of the examination and the percentage obtained. The scope of the examination will be as hereinafter stated; the qualifying mark for classification as first and second class gunner will be in each case not less than an average of 75 per cent, and for expert gunners the qualifying mark in case of the selected subject will not be less than an average of 80 percent.

SECTION III.
ELIGIBILITY OF CANDIDATES.

3. **Eligibility of candidates.**—Any enlisted man of the Coast Artillery Corps whose company or detachment commander certifies that his character is at least equal to "good" is eligible for examination for qualification as a second

class gunner. Candidates for first class gunners must have previously qualified as second class gunners, and, similarly, candidates for expert gunners must have qualified as first class gunners, though all qualifications may be made at the same examination.

SECTION IV.
INSTRUCTION OF CANDIDATES.

4. **Instruction of candidates.**—Prior to the examination for gunners, and in preparation therefor, brigade, coast defense, regimental, and detachment commanders will cause, in so far as practicable, all Coast Artillerymen of their commands to be carefully instructed in the prescribed subjects. Ordinarily the indoor season will be utilized, in part, for this instruction.

SECTION V.
BOARDS OF EXAMINATION.

5. **By whom convened.**—Boards of examination will be convened annually by brigade, coast defense, and regimental commanders. Enlisted men of the Coast Artillery not members of the command of the convening authority and for whom provision for examination has not otherwise been made will be examined, upon application, and if found qualified, will be announced as gunners by the authority convening the board conducting their examination. In case it is not practicable for enlisted men of the Coast Artillery who are on duty other than with a Coast Artillery command to present themselves for examination to one of the boards heretofore mentioned, the Corps Area or Department Commander will convene boards of Coast Artillery Officers to conduct the examinations, and will announce the gunners as a result of these examinations.

6. **Composition of boards.**—The examining board will consist when practicable, of three Coast Artillery Officers. When a company commander is a member of a board he will be relieved by another officer during the examination of candidates from his company. Examining boards convened by Corps Area or Department Commanders may consist of one or more Coast Artillery officers as in their judgment best meets the needs of the service.

SECTION VI.
CONDUCT OF THE EXAMINATION.

7. **How conducted.**—Boards convened by coast defense or regimental commanders will conduct the examinations by company attaching extra men to companies for the examinations. Detachments serving in the coast defense or with a regiment will be regarded as companies for the purpose of examination. Boards convened by brigade or corps area commanders will conduct the examination in such manner as will best meet the demands of the particular case.

8. **Where held.**—The examination of gunner candidates will be held as far as practicable at such places as the matériel pertaining to the subject in hand is located, and will be made as practical as possible. In determining the qualification of candidates credit will be given for practical knowledge of subjects, rather than for text books answer to questions.

9 **Progress of examination.**—Whenever, during the progress of the examination of a candidate the sum of the marks received on subjects for which he has already been examined, increased by the maximum allowed for the remaining subjects is less than required for qualification he will be disqualified and his examination will be discontinued. Whenever during the progress of the examination of a candidate the sum of the marks received on the subjects in which he has already been examined is sufficient for qualification he may be qualified without further examination.

10. **Records kept.**—The board will keep a record of its marks during the examination and, at its close, submit same to the convening authority, but these marks will not be published in orders.

SECTION VII.
REPORT OF THE BOARD OF EXAMINATION.

13. **Report of the board.**—The report of the board on each company or detachment will be sent, as soon as practicable, after the completion of the examination, to the convening authority who will publish an order announcing the names of those who have qualified as gunners, the grade in which qualification was made, and the date of qualification. The date of the completion of the examination of the company or detachment concerned will be taken as the date of qualification.

SECTION VIII.
SCOPE OF THE EXAMINATION.

12. **General.**—The scope of the examination of candidates for gunners will be that prescribed for the particular organization to which the candidate is assigned or attached. For candidates not on duty with an organization the candidate may elect to take any one set of the authorized examinations. The examination of candidates for expert gunners will be conducted with such thoroughness as to assure that, for qualification, the candidate has a good practical knowledge of the subject and further that he has the ability to impart that knowledge to others.

13. **Gun companies.**—For candidates in companies assigned to gun defense.

a. For second class gunners:

(1) Service of the piece (practical). This will include an actual drill at the battery in which the candidate will in turn perform the duties of various numbered cannoneers, the range setter, the chief of breech, the elevation setter (mortars only), and the azimuth setter (mortars only), or as many of those duties as the board may direct..... 40

(2) Nomenclature of the various parts of the gun and carriage..... 5
(3) Action, adjustment, and care of the various parts of guns and carriages..... 20
(4) Powders, projectiles, primers, and fuses..... 10
(5) Cordage, gins, shears, and jacks..... 10
(6) United States magazine rifle..... 15
100

b. For first class gunners:

(1) The azimuth instrument (Theoretical, 5; practical, 10)..... 15
(2) Duties in the plotting room (theoretical, 20; practical, 30). The candidate will act in turn as Nos. 1, 2, 3, 4, and 5 while tracking a moving target (if practicable), or in as many of those positions as the board may direct..... 50
(3) Aiming and laying guns or mortars, practical..... 15
(4) Use and care of telephones..... 10
(5) Definitions for Coast Artillery..... 5
(6) War ships, characteristic features..... 5
100

c. The examination of candidates for first-class gunners of organizations assigned exclusively to rapid-fire guns not provided with separate position finding system will include the following head in lieu of those given under (2):

(2) Subcaliber firing..... 50

d. The examination in subjects (1), (2), (3), and (4) for both second-class and first class gunners will be confined to the matériel of that part of the defense to which the company is assigned. If no azimuth instrument is included in the battery equipment, the instrument used in the instruction will be used in the examination.

e. For expert gunners the candidate will be required to pass in one of the following subjects:

Duties of Gun Commander and Gun Pointer:

(1) Definitions for Coast Artillery..... 5
(2) Gun and carriage..... 20
  (*a*) Adjustment of—
  Quadrant elevation device, sight standard, throttling valve, gas check pad, elevating gear, grease cups, and firing mechanism.
  (*b*) Care and preservation, including care of hand counterweights, oiling and painting, packing, stuffing and cleaning recoil cylinders.
(3) Powders, projectiles, fuses, and primers..... 10
  (*a*) Blending powder and preparation of powder charges.
  (b) Filling and fusing projectiles.
  (*c*) Painting projectiles.
(4) Preparation for service or subcaliber practice..... 10
(5) Precautions for safety at the battery..... 5
(6) Pointing..... 20
  (*a*) Methods of pointing and pointing tests.
  (*b*) The telescope sight (the quadrant for mortars).....
  (*c*) Emergency system and salvo points.
  (*d*) Bore sighting and orientation.
(7) Regulations governing service and subcaliber practices so far as they affect the service at the emplacements..... 5
(8) Mounting and dismounting guns and carriages..... 20

(9) Characteristic features of the several classes of warships, general knowledge of local shipping, of channels leading to the harbor, and of ranges to prominent fixed objects in the field of fire of the battery 5

100

Duties of plotter:

(1) Definitions for Coast Artillery 10

(2) Position finding system 25

(*a*) Detailed knowledge of system employed at the battery.

(*b*) Indication and identification of targets.

(*c*) Duties of each member of the range section under all conditions.

(*d*) Emergency system and salvo points.

(3) Position finding apparatus 25

(*a*) Detailed knowledge of adjustments and use of all position finding apparatus used in the plotting room.

(4) Elementary gunnery 25

(*a*) Explanation of the several corrections to be applied to the observed range to obtain the corrected range.

(*b*) Effect on the flight of the projectile of varations in the density of the air; the direction and velocity of the wind.

(5) Records and reports 15

To include an intimate knowledge of the details of analysis of drill and target practice.

100

Duties of observer:

(1) Definitions for Coast Artillery 10

(2) Position finding system 40

(*a*) Detailed description of that in use at the battery.

(*b*) Indication and identification of targets.

(*c*) Emergency system and salvo points.

(*d*) Detailed knowledge of spotting system in use at battery.

(3) Position finding apparatus 40

(*a*) A detailed knowledge of adjustment and use of all observing instruments and range finders in use at the battery.

(*b*) Use of the telephone.

(4) Characteristic features of the several classes of warships, general knowledge of local shipping, of channels leading to the harbor, and of ranges to prominent fixed objects in the field of fire of the battery 10

100

14. **Mine companies.**—For candidates in companies and detachments assigned to mine defense:

a. For second class gunners:

(1) Ammunition, nomenclature, and service of guns to which the candidate's company is assigned. (In case the company is not assigned to a battery, the coast defense commander will designate a battery to which the company is likely to be assigned in time of war.) 15

(2) Equipment, material and duties in the loading room (except electrical principles involved) 30

(3) Material for and duties on the water 30

(4) Cordage, gins, shears, and jacks 10

(5) United States magazine rifle 15

100

b. For first class gunners:

(1) Care and preservation of mine material 15

(2) Handling and storage of high explosives 20
(3) Knowledge and use of the azimuth instrument and plotting board. 20
(4) Engines, generators, transformers, storage batteries, and searchlights assigned to the company of which the candidate is a member 20
(5) Operation of casemate apparatus and of telephones 20
(6) Definitions for Coast Artillery 5
100

c. *For expert gunner* the candidates will be required to pass in one of the following subjects:

Duties of casemate electrician:
(1) Definitions for Coast Artillery 10
(2) Casemate apparatus 40
(*a*) Nomenclature.
(*b*) Testing.
(*c*) Circuits.
(*d*) Maintenance.
(3) Troubles and remedies 40
(*a*) Lamps and bells.
(*b*) Switches.
(*c*) Ammeters, and voltmeters.
(*d*) Telephones.
(*e*) Engines and machines.
(4) Firing 10
(*a*) Observation.
(*b*) Contact.
(*c*) Delay contact.
100

Duties of chief planter.
(1) Definitions for Coast Artillery 5
(2) Mine planting matériel 35
(*a*) Voltmeter test of a mine circuit.
(*b*) Hydraulic jacks.
(*c*) Nomenclature and use of apparatus aboard mine planters used in planting mines.
(*d*) Capacity of falls and winches.
(*e*) Automatic anchor.
(3) Planting mines 35
(*a*) Duties of noncommissioned officer in distribution box boat.
(*b*) Duties of each member of the planter detail during planting and raising of mines.
(*c*) Boat drill with yawl boat.
(4) Emergencies 10
(5) Cordage 15
100

Duties of chief loader:
(1) Definitions for Coast Artillery 5
(2) Explosives (except powders) 15
(*a*) Storing, handling, and inspecting in general.
(*b*) Trotol; handling and care.
(3) Fuses (detonators) 15
(*a*) Description, storage and handling.
(*b*) Tests.
(*c*) Preparation for use in compound plugs.
(4) Loading room duties 50

(*a*) General; tools, supplies and caretaking.
(*b*) Mine transformers; storage and care, testing and measuring resistance of circuits.
(*c*) Preparation of trotol primers.
(*d*) Assembling and testing compound plugs.
(*e*) Loading mines and delivering to planter.
(*f*) Preparing and loading sub-mines.
(*g*) Records.

(5) Unloading mines 15
(*a*) Handling and unloading mines, stripping compound plugs, safety precautions.
(*b*) Disposal of explosive. 100

15. **Gun battery, antiaircraft.**—For candidates assigned to gun battery, antiaircraft:

a. For second class gunners:
(1) Identification of aircraft 10
(2) Cordage and mechanical maneuvers 10
(3) Automatic pistol, operation, care, assembling and disassembling .. 15
(4) Service of the piece, this to include ammunition, fuses and projectiles 35
(5) Telephone communication, laying wire, making telephone connections and tests 20
(6) General nomenclature of guns and range instruments 10
100

b. For first class gunners:
(1) Operation and care of all fire control instruments, duties of all members of range section in determining and transmitting firing data to the guns 50
(2) Adjustments of recoil system, adjustment and use of sights, and of range disc; preservation of matériel 15
(3) Nomenclature, care, operation and driving of motor transportation, (general theory and repair of gasoline engines) 35
100

c. For expert gunners: The candidate will be required to pass in one of the following subjects:

Duties of communications sergeant:
(1) System of communications, including a thorough knowledge of duties of lineman, telephone, and switchboard operator 20
(2) Visual signalling 10
(3) Elementary principles of electricity and magnetism 10
(4) Installation of complete field telephone system, including utilization of natural features of terrain in obtaining concealment and protection 20
(5) Location of faults, tests for grounds and short circuits 20
(6) Installation and operation of message centers, coding and decoding 20
100

Duties of maintenance sergeant.
(1) Principles of internal combustion engines including nomenclature, care, operation, maintenance, lubrication, location of sources of trouble, and the making of minor repairs 30
(2) Care, operation, and adjustment of transmission gears, differentials, clutches, cooling systems, spark plugs, magnetos, storage batteries, timing devices, carburetors, valves, governors, and steering mechanisms 20
(3) Motor driving and training of chauffeurs 20

(4) Loads and their proper distribution..... 10
(5) Rules of the road, convoy regulations, road discipline, speed laws, and regulations, parking..... 10
(6) Records and reports..... 10

100

Duties of gun commander:
(1) Definitions..... 5
(2) Guns and carriages..... 20
(*a*) Nomenclature, function and action of the several parts.
(*b*) Packing stuffing boxes; draining, cleaning and filling recoil cylinders and recuperators.
(*c*) Adjustment of sight scales, range discs, levelling devices, breech blocks and firing mechanisms.
(3) Preparations for subcaliber and service practice and regulations governing same in so far as they affect service at the piece..... 10
(4) Pointing, to include—..... 25
(*a*) Methods of pointing and pointing tests.
(*b*) The antiaircraft gun sight, and the range disc.
(*c*) Bore sighting, and orientation.
(*d*) The use of range tables or trajectory charts.
(*e*) Methods of firing trial shots.
(5) Mounting and dismounting piece and carriage, emplacing piece, and preparing for action, withdrawing from action, and taking up "March order"..... 15
(6) Records and reports..... 5
(7) Organization of a position..... 10
(*a*) Camouflage.
(*b*) Shelters.
(*c*) Communications.
(8) Convoys..... 10
(*a*) Signals.
(*b*) Traffic rules and regulations.
(*c*) March discipline.

100

Duties of chief of range section.:
(1) Definitions..... 10
(2) Methods of determining firing data including a detailed knowledge of the system in use and of the operation and adjustment of all instruments required for the system..... 40
(3) Elementary gunnery, including—..... 40
(*a*) Explanation of the several corrections to be applied to the initial fuse range reading to obtain the final fuse range reading.
(*b*) Effect on the flight of the projectile of variations in the density of the air, and in the direction and velocity of the wind.
(*c*) Use of trial shots or salvos and data obtained from them.
(4) Records and reports. An intimate knowledge of the details of analyses of drill and target practice..... 10

100

Duties of observer:
(1) Definitions..... 10
(2) Methods of determining firing data including a thorough understanding of the principles of the methods in use, and a detailed knowledge of the adjustment, care and operation of all observing instruments used..... 40

(3) Indication and identification of targets, including characteristic features of the several classes of aircraft..... 20
(4) Records and reports..... 10
(5) Detailed knowledge of duties at drill, and at subcaliber and service practice..... 20

100

16. **Searchlight battery, antiaircraft.**—For candidates assigned to searchlight battery, antiaircraft:

a. For second class gunners:

(1) Identification of aircraft..... 10
(2) Cordage and mechanical maneuvers. 10
(3) Automatic pistol, operation, care, assembling and disassembling.. 15
(4) Drill of the light squad..... 35
(5) Telephone communication, laying wire, making telephone connections, and tests..... 20
(6) Nomenclature of lights..... 10

100

b. For first class gunners:

(1) General theory, care and operation of engines, generators, and storage batteries..... 25
(2) Operation, care, adjustment and preservation of lights, preparing light emplacements..... 40
(3) Nomenclature, care, operation and driving of motor transportation 35

100

c. For expert gunner: The candidate will be required to pass in one of the following subjects:

Duties of communications sergeant:

(1) System of communications, including a thorough knowledge of duties of lineman, telephone, and switchboard operator..... 20
(2) Visual signalling..... 10
(3) Elementary principles of electricity and magnetism..... 10
(4) Installation of complete field telephone system, including utilization of natural features of terrain in obtaining protection and concealment..... 20
(5) Location of faults. Tests for grounds and short circuits..... 20
(6) Installation and operation of message centers, coding and decoding 20

100

Duties of maintenance sergeant:

(1) Principles of internal combustion engines including nomenclature, care, operation, maintenance, lubrication, location of sources of trouble, and the making of minor repairs..... 30
(2) Care, operation, and adjustment of transmission gears, differentials, clutches, cooling systems, spark plugs, magnetos, storage batteries, timing devices, carburetors, valves, governors and steering mechanisms..... 20
(3) Motor driving, and training of chauffeurs..... 20
(4) Loads and their proper distribution..... 10
(5) Rules of the road, convoy regulations, road discipline, speed laws and regulations, parking..... 10
(6) Records and reports..... 10

100

Duties of searchlight electrician:

(1) Definitions 10
(2) Searchlight apparatus 45
  (*a*) Nomenclature.
  (*b*) Testing.
  (*c*) Circuits.
  (*d*) Maintenance.
(3) Troubles and remedies 45
  (*a*) Lamps.
  (*b*) Switches.
  (*c*) Ammeters and voltmeters.
  (*d*) Telephones.
  (*e*) Engines and machines.

100

Duties of plotter:

(1) Definitions and essential terms special to antiaircraft defense ... 10
(2) Position finding system 45
  (*a*) Detailed knowledge of the systems employed by the battery.
  (*b*) Indication and identification of targets.
  (*c*) Duties of each member of detail for position finding apparatus under all conditions.
(3) Emergency systems 15
(4) Detailed knowledge of the adjustment and operation of all position finding apparatus employed by the battery 20
(5) Plotter's tests 10

100

17. **Machine gun battery, antiaircraft.**—For candidates assigned to machine gun battery, antiaircraft:

a. For second class gunners:

(1) Identification of aircraft 10
(2) Cordage and mechanical maneuvers 10
(3) Automatic pistol, operation, care, assembling and disassembling .. 15
(4) Service of the piece, this to include ammunition 30
(5) Telephone communications, laying wire, making telephone connections, and tests 20
(6) Nomenclature, assembling and disassembling of machine gun and belt filling machine 15

100

b. For first class gunners:

(1) Selection of positions, preparing emplacements, and necessary emergency trenches 20
(2) Range and fire control instruments, methods of fire, determining and transmitting firing data to guns 25
(3) Nomenclature, care, operation and driving of motor transportation 35
(4) Care and adjustment of guns and mounts, procedure in case of stoppages, setting and adjusting sights 20

100

c. For expert gunners: The candidate will be required to pass in one of the following subjects:

Duties of communications sergeant:

(1) System of communications, including a thorough knowledge of duties of lineman, telephone and switchboard operator 20
(2) Visual signalling 10

(3) Elementary principles of electricity and magnetism..... 10
(4) Installation of complete field telephone system, including utilization of natural features of terrain in obtaining protection and concealment..... 20
(5) Location of faults, tests for grounds and short circuits..... 20
(6) Installation and operation of message centers, coding and decoding 20
100

Duties of maintenance sergeant:

(1) Principles of internal combustion engines including nomenclature, care, operation, maintenance, lubrication, location of sources of trouble, and the making of minor repairs..... 30
(2) Care, operation, and adjustment of transmission gears, differentials, clutches, cooling systems, spark plugs, magnetos, storage batteries, timing devices, carburetors, valves, governors, and steering mechanisms..... 20
(3) Motor driving, and training of chauffeurs..... 20
(4) Loads and their proper distribution..... 10
(5) Rules of the road, convoy regulations, road discipline, speed laws, and regulations, parking..... 10
(6) Records and reports..... 10
100

Duties of observer:

(1) Definitions..... 10
(2) Position finding and observation systems..... 50
  (*a*) Detailed knowledge of the position finding and observation systems employed by the battery.
  (*b*) Indication and identification of targets.
  (*c*) Observers' tests.
  (*d*) Detailed knowledge of the adjustment and operation of all position finding and observing instruments provided for the battery.
  (3) Records and reports..... 10
(4) Detailed knowledge of operation, care and adjustment of all range finding equipment assigned to the battery..... 30
100

Duties of chief of section:

(1) Definitions..... 5
(2) Machine gun and mounts..... 35
  (*a*) Nomenclature, function and action of various parts.
  (*b*) Packing the gun and cleaning recoil mechanism.
  (*c*) Use and adjustment of sights, sight scales, adjustment of firing mechanisms.
(3) Preparations for service practice and regulations governing same in so far as they affect the service of the machine guns..... 15
(4) Safety precautions..... 10
(5) Pointing—methods of direct and indirect pointing..... 10
(6) Organization of a position..... 10
(7) Convoys..... 10
  (*a*) Signals.
  (*b*) Traffic rules and regulations.
  (*c*) March discipline.
(8) Records and reports..... 5
100

18. **Headquarters detachment and combat train, antiaircraft.**—For candidates assigned to headquarters detachments and combat train, antiaircraft:

a. For second class gunners:

(1)	Identification of aircraft	10
(2)	Cordage and mechanical maneuvers	10
(3)	Automatic pistol, operation, care and assembling and disassembling	15
(4)	Telephone communication, wire laying, cable splicing, making telephone connections and tests	25
(5)	General nomenclature and elementary principles of motor transportation	15
(6)	Use of the telephone, methods of sending, receiving and recording messages	25
		100

b. For first class gunners:

(1)	General information concerning each organization in the battalion as to strength of command, material served, types and amount of transportation used	10
(2)	Telephones: Repair of troubles, nomenclature, operation and care of monocord switchboard and all types of field telephones	40
(3)	Nomenclature and operation of observing instruments	10
(4)	Nomenclature, care, operation and driving of motor transportation. Convoy work	40
		100

c. For expert gunner: The candidate will be required to pass in one of the following subjects:

Duties of communications sergeant:

(1)	System of communications, including a thorough knowledge of duties of lineman, telephone, and switchboard operator	20
(2)	Visual signalling	10
(3)	Elementary principles of electricity and magnetism	10
(4)	Installation of complete field telephone system, including utilization of natural features of terrain in obtaining protection and concealment	20
(5)	Location of faults, tests for grounds and short circuits	20
(6)	Installation and operation of message centers, coding and decoding	20
		100

Duties of maintenance sergeant:

(1)	Principles of internal combustion engines, including nomenclature, care, operation, maintenance, lubrication, location of sources of trouble, and the making of minor repairs	30
(2)	Care, operation, and adjustment of transmission gears, differentials, clutches, cooling systems, spark plugs, magnetos, storage batteries, timing devices, carburetors, valves, governors, and steering mechanisms	20
(3)	Motor driving, and training of chauffeurs	20
(4)	Loads and their proper distribution	10
(5)	Rules of the road, convoy regulations, road discipline, speed laws, and regulations, parking	10
(6)	Records and reports	10
		100

Duties of observer:

(1)	Definitions	10
(2)	Position finding and observation systems	50

(*a*) Detailed knowledge of the position finding and observation systems employed by the battalion.
(*b*) Indication and identification of targets.
(*c*) Observers tests.
(*d*) Detailed knowledge of the adjustment and operation of all position finding and observing instruments provided for the battalion.

(3) Records and reports 10
(4) Detailed knowledge of operation, care and adjustment of all range finding equipment assigned to the battalion 30
100

19. **Railway artillery batteries.**—For candidates assigned to railway artillery batteries.:

a. For second class gunners:

(1) Service of the piece (practical), to include the actual drill at the piece. The candidate will, in turn, perform the duties of such members of the gun section as the board may require 30
(2) Nomenclature of the various parts of the gun and carriage 5
(3) Action, adjustment, and care of the various parts of the gun and carriage 15
(4) Powders, projectiles, primers and fuses 5
(5) Cordage, gins, shears, jacks, platforms and cribbing 15
(6) United States magazine rifle or pistol 5
(7) Nomenclature of material used for ground platforms, practical knowledge of emplacement of mount for firing 15
(8) Nomenclature of railroad track material; practical knowledge of packing journal boxes; brake mechanisms, buffers and couplings. 10
100

b. For first class gunners:

(1) The azimuth instrument or similar land observation instrument .. 15
(2) Duties in plotting car for both land and water firing 50
(3) Aiming and laying (practical) 15
(4) Definitions for Coast Artillery and characteristic features of warships 10
(5) Use and care of telephone 10
100

c. For expert gunners: The candidate will be required to pass in one of the following subjects.:

Duties of gun commander and gun pointer:

(1) Definitions for Coast Artillery 5
(2) Gun and carriage 20
(*a*) Nomenclature, purpose and action of several parts.
(*b*) Inspection and maintenance of the carriage. To include dismounting, care, cleaning, and adjusting the recoil, recuperator, elevating and traversing mechanisms.
(*c*) Inspection and maintenance of the gun; to include dismounting, care, preservation, and cleaning of the gun; also dismounting, care and adjustment of the breech and firing mechanisms.
(*d*) Adjustment of elevation quadrant and bracket and the panoramic sight and bracket.
(3) Railway cars 10
(*a*) Nomenclature, care and operation of trucks, hand brakes, air brakes, couplers and draft gear.

(*b*) Preparation of matériel for movement.
(4) Emplacement of the mount for firing 20
(*a*) Use of standard gauge equipment.
(*b*) Use of narrow gauge equipment (only for batteries so equipped).
(5) Powders, projectiles, fuses, and primers 5
(*a*) Preparation of powder charges.
(*b*) Filling and fusing projectiles.
(*c*) Primers.
(*d*) Painting projectiles.
(6) Service of the piece 10
(*a*) Duties of each member of the gun section under all conditions.
(7) Safety precautions 5
(*a*) Before firing.
(*b*) During firing.
(8) Pointing 5
(*a*) Methods of aiming and laying.
(9) Characteristic features of the several classes of warships 5
(10) Organization of a position 15
(*a*) Camouflage.
(*b*) Shelters.
(*c*) Gun defense.
(*d*) Protection against aircraft.
(*e*) Communications. 100

Duties of observer:
(1) Definitions for Coast Artillery 5
(2) Position finding system 30
(*a*) Detailed description of that in use at the battery.
(*b*) Indication and identification of targets.
(*c*) Detailed knowledge of spotting system in use at the battery.
(3) Position finding apparatus 30
(a) Detailed knowledge of adjustment and use of all observing instruments and range finders in use at the battery.
(*b*) Use of the telephone.
(4) Characteristic features of the several classes of warships 5
(5) Map reading 10
(6) Methods of observation 10
(*a*) Unilateral.
(*b*) Bilateral.
(*c*) Balloon.
(*d*) Airplane.
(7) General duties of observers in observation posts 10
(*a*) Land warfare.
(*b*) Seacoast warfare. 100

Duties of plotter:
(1) Definitions for Coast Artillery 10
(2) Position finding system 25
(*a*) Detailed knowledge of systems employed in the battery.
(*b*) Indication and identification of targets.
(*c*) Duties of each member of the range section under all conditions.
(*d*) Emergency system employed at the battery.
(*e*) Knowledge of use of protracters, scales, conversion from one unit of angular measure to another. Ability to read topographical maps and locate points thereon.

(3) Position finding apparatus..... 25
(a) A detailed knowledge of adjustment, care, and use of all position finding apparatus used in the plotting car.
(4) Elementary gunnery..... 25
(a) Explanation of the several corrections to be applied to the true range to obtain the corrected range.
(b) Effect on the flight of the projectile of variations in the density of air; direction and velocity of wind. The meteorological message and how to apply it.
(c) Kinds of observation.
Unilateral. Balloon.
Bilateral. Airplane.
(5) Preparation of reports and target practice records; to include an intimate knowledge of the details of analysis of drill and target practice..... 15

100

Duties of railway sergeant:

(1) Railway cars..... 40
(a) Nomenclature, purpose and action of the several parts.
(b) Inspection of matériel to include journal boxes, couplings, air brakes, centrifugal dirt collectors, hand brakes, brake shoes, and wheels.
(c) Maintenance of matériel including adjustment of matériel, minor repairs, replacements, and packing journal boxes.
(2) Railway movements..... 30
(a) Practical understanding of manuals, orders and regulations on car operation.
(b) Duties of train conductor to include arrangements for guards in personnel cars and on all open cars loaded with matériel, information relative to weights, contents, clearances, classes and numbers of cars in his train.
(c) Safety precautions for personnel during movements.
(3) Track construction..... 20
(a) Nomenclature of track matériel.
(b) Practical knowledge of track and spur construction.
(4) Loading and unloading cars..... 10
(a) Practical knowledge of Field Service Rrgulations on subject. 100

20. **Tractor artillery batteries.**—For candidates assigned to tractor artillery batteries:

a. *For second class gunners:*

(1) Service of the piece (practical), to include the actual drill at the piece. The candidate will, in turn, perform the duties of such members of the gun section as the board may require..... 30
(2) Nomenclature of the various parts of the gun and carriage..... 5
(3) Action, adjustment, and care of the various parts of the gun and carriage..... 15
(4) Powders, projectiles, primers, and fuses..... 5
(5) Cordage, gins, shears, jacks and mechanical maneuvers..... 15
(6) Automatic pistol..... 5
(7) Use and care of telephone..... 10
(8) Practical driving of motor vehicle..... 15

100

b. For first class gunners.

(1) Use, orientation and adjustment of fire control instruments..... 10
(2) Duties of each member of the range section..... 35
(3) Aiming and laying guns..... 10
(4) Care, service, repair and operation of trucks and tractors..... 30
(5) Map reading and sketching..... 10
(6) Definitions for Coast Artillery..... 5

100

c. For expert gunner the candidate will be required to pass in one of the following subjects:

Duties of gun commander and gun pointer:

(1) Definitions for Coast Artillery..... 5
(2) Gun and carriage..... 25
  (*a*) Nomenclature, purpose and action of parts.
  (*b*) Inspection and maintenance; to include dismounting, care, cleaning and adjusting of the several parts of the gun and carriage.
(3) Emplacement..... 25
(*a*) Preparation of position, to include shelter trenches, ammunition pits and camouflage.
  (*b*) Occupation of and withdrawal from position, to include actually placing the gun in and out of position and the observation of camouflage discipline.
  (*c*) Maneuvering, to include various methods of maneuvering gun in and out of position and on the march and the use of maneuvering *matériel*, cordage, tackles, jacks, man-power and tractor.
  (*d*) Protection against aircraft.
(4) Ammunition..... 5
  (*a*) Storage and care of ammunition.
  (*b*) Composition of powder charges.
  (*c*) Primers and fuses.
  (*d*) Fusing and preparation of projectiles for firing.
  (*e*) Painting of projectiles.
(5) Service of the piece..... 10
  (*a*) Duties of each member of the gun section under all conditions.
(6) Safety precautions..... 5
  (*a*) Before firing.
  (*b*) During firing.
(7) Characteristic features of the several classes of warships..... 5
(8) Pointing..... 5
  (*a*) Methods of aiming and laying.
(9) Map reading..... 10
  (*a*) Scales, contours and conventional signs.
  (*b*) Location of a position by coordinates.
  (*c*) Follow routes indicated on the map.
(10) Road marches and march discipline..... 5

100

Duties of motor sergeant:

(1) Principle of internal combustion engines including nomenclature, care, operation, maintenance, lubrication, location of sources of trouble and the making of minor repairs..... 30

(2) Care, operation, and adjustment of transmission gears, differentials, clutches, cooling systems, spark plugs, magnetos, storage batteries, timing devices, carburetors, valves, governors, and steering mechanisms 20
(3) Loads and their proper distribution 10
(4) Motor driving and training of chauffeurs 20
(5) Rules of the road, convoy regulations, and discipline, speed laws and regulations, parking 10
(6) Records and reports 10
100

Duties of observer:
(1) Definitions for Coast Artillery 5
(2) Position finding system 30
(*a*) Detailed description of that in use at the battery.
(*b*) Indication and identification of targets.
(*c*) Detailed knowledge of spotting system in use at the battery.
(3) Position finding apparatus 30
(*a*) Detailed knowledge of adjustment and use of all observing instruments and range finders in use at the battery.
(*b*) Use of the telephone.
(4) Characteristic features of the several classes of warships 5
(5) Map reading 10
(6) Methods of observation 10
(*a*) Unilateral.
(*b*) Bilateral.
(*c*) Balloon.
(*d*) Airplane.
(7) General duties of observers in observation posts 10
(*a*) Land warfare.
(*b*) Seacoast warfare.
100

21. **Sound ranging companies.**—For candidates assigned to sound ranging companies:

a. For second class gunners:
(1) Installation, care and upkeep of outpost and listener lines, to include: joint making, climbing, wire tension, building of listener screens, installation of microphones 40
(2) Duties of rodman and chainman (practical) 20
(3) Cordage, gins and shears 10
(4) Loading and care of motor vehicles 15
(5) U. S. automatic pistol, Cal. 45 or light machine gun 15
100

b. For first class gunners:
(1) Nomenclature, care, set-up and operation of Bull Tucker recording instrument, with elementary theory of sound ranging 30
(2) Storage batteries, engine and generator 15
(3) Duties of computing section, construction of plotting board, duties of plotter 30
(4) Telephones and information net-work 10
(5) Azimuth instrument or transit (theoretical and practical) 15
100

c. For expert gunner the candidate will be required to pass in one of the following subjects:

Duties of chief of survey section.

(1) Definitions, Sound Ranging Service..... 10
(2) Sound ranging system..... 30
  (*a*) Detailed knowledge of the sound ranging layout employed by the company including outpost and listener location, wiring scheme, and special functions of the survey, casemate, wiring, transportation, and headquarters section.
  (*b*) Selection of sound records to be plotted.
  (*c*) Duties of each man in casemate and survey section.
  (*d*) Knowledge and practical application of asymptote, wind, density, temperature and altitude corrections.
(3) Sound ranging apparatus..... 30
  (*a*) General knowledge of recording equipment used by the company.
  (*b*) Detailed knowledge of installation, adjustment and use of sound and time recording apparatus.
  (*c*) Construction and use of special sound ranging plotting boards.
  (*d*) Preparation and use of special forms pertaining to sound records.
  (*e*) Mixing of solution for developing and fixing camera records.
(4) Elementary knowledge of flash ranging..... 10
(5) Surveying..... 20
  (*a*) Elementary principles.
  (*b*) Special knowledge of map reading. 100

Duties of chief of casemate section:

(1) Definitions, Sound Ranging Service..... 10
(2) Sound ranging system..... 20
  (*a*) Detailed knowledge of the sound ranging layout employed by the company including outpost and listener location, wiring scheme, and special functions of the survey, casemate, wiring, transportation, and headquarters section.
  (*b*) Practical switchboard operation.
(3) Sound ranging apparatus..... 30
  (*a*) General knowledge of recording equipment used by the company.
  (*b*) Detailed knowledge of all casemate apparatus used by the company, including nomenclature, testing, circuits, maintenance and operation.
(4) Elementary knowledge of flash ranging..... 10
(5) Troubles and remedies..... 30
  (*a*) Storage batteries.
  (*b*) Switches and relays.
  (*c*) Ammeters and voltmeters.
  (*d*) Telephones.
  (*e*) Charging sets. 100

Duties of chief of wiring section:

(1) Definitions, Sound Ranging Service..... 10
(2) Sound ranging system..... 25
  (*a*) Detailed knowledge of the sound ranging layout employed by the company including outpost and listener location, wiring scheme, and special functions of the survey, casemate, wiring, transportation and headquarters sections.
  (*b*) Selection of sounds to be recorded.

(c) Identification of targets, land and water.

(3) Sound ranging apparatus 25
   (a) General knowledge of recording equipment used by the company.
   (b) Detailed knowledge of azimuth instruments and transits used by the company.
   (c) Detailed knowledge of outpost sets and telephones used by the company.

(4) Laying, patrolling, maintaining and salvaging lines 10

(5) Selection of routes for wiring, (practical) 25

(6) Telephones 5
   (a) Care.
   (b) Tests.
   (c) Use.

100

Duties of motor sergeant:

(1) Principle of internal combustion engines including nomenclature, care, operation, maintenance, lubrication, location of sources of trouble and the making of minor repairs 30

(2) Care, operation, and adjustment of transmission gears, differentials, clutches, cooling systems, spark plugs, magnetos, storage batteries, timing devices, carburetors, valves, governors and steering mechanisms 20

(3) Motor driving, and training of chauffeurs 20

(4) Loads and their proper distribution 10

(5) Rules of the road, convoy regulations, and discipline, speed laws, and regulations, parking 10

(6) Records and reports 10

100

44. **Trench mortar battery.**—For candidates assigned to trench mortar battery:

a. For second class gunners:

(1) Installation and service of the mortar 25

(2) Ammunition 10

(3) Cordage, gins, jacks and shears 10

(4) Pistol and automatic rifle 10

(5) Use of the telephone, laying wire, including making joints 10

(6) Practical driving of motor vehicles 10

(7) Aiming and laying mortar 25

100

b. For first class gunners:

(1) Orientation, care and adjustment of observing instruments 25

(2) Map reading and sketching 25

(3) Care, maintenance and operation of communication equipment 25

(4) Care, maintenance and operation of motor equipment 25

100

c. For expert gunner the candidate will be required to pass in one of the following subjects:

Duties of gun comander:

(1) Definitions 10

(2) Mortar and platform 10
   (a) Nomenclature, purpose and action of several parts.
   (b) Care and preservation—oiling and painting.
   (c) Transportation of the mortar matériel, by truck and by hand.

(3) Propelling and bursting charges, shell, fuses and misfire charges.. 10
(*a*) Preparation of the charge for loading.
(*b*) Filling and fusing of projectiles.
(*c*) Painting of projectiles.
(*d*) Transportation, care and storage of ammunition.
(4) Service practice..... 15
(*a*) Preparation for service practice.
(*b*) Regulations governing service practice so far as they affect the service of the emplacements.
(*c*) Records and reports.
(5) Service of the piece..... 25
(*a*) Duties of each member of mortar section.
(*b*) Precautions for safety.
(*c*) Irregularities of fire and means to prevent.
(*d*) Methods of aiming and laying.
(6) Emplacement, to include selection and location of positions, emplacement of the mortar and preparation of the position, establishing the mortar on the base line, camouflage, gas protection, field fortifications..... 30
100

Duties of observer:
(1) Definitions..... 5
(2) Location, construction and occupation of observation stations, to include camouflage, gas protection..... 10
(3) Observation of fire.....25
(*a*) Principles of observation.
(*b*) Methods of observation.
(*c*) Adjustment of fire.
(*d*) Report of observation by telephone, visual signals and runners.
(4) Combat intelligence..... 15
(*a*) Mission.
(*b*) Observation.
(5) Reconnaissance, map reading and military sketching..... 20
(6) Preparation and use of charts and firing boards..... 15
(7) Preparation and transmission of messages and reports, to include records and reports of service practice..... 5
(8) Use, care and maintenance of topographic, observing and communication equipment..... 5
100

Duties of motor sergeant:
(1) Principle of internal combustion engines including nomenclature, care, operation, maintenance, lubrication, location of sources of trouble and the making of minor repairs..... 30
(2) Care, operation, and adjustment of transmission gears, differentials, clutches, cooling systems, spark plugs, magnetos, storage batteries, timing devices, carburetors, valves, governors, and steering mechanisms..... 20
(3) Motor driving , and training of chauffeurs..... 20
(4) Loads and their proper distribution..... 10
(5) Rules of the road, convoy regulations, and discipline, speed laws, and regulations, parking..... 10
(6) Records and reports..... 10
100